The Solar FuelSaver™ Series

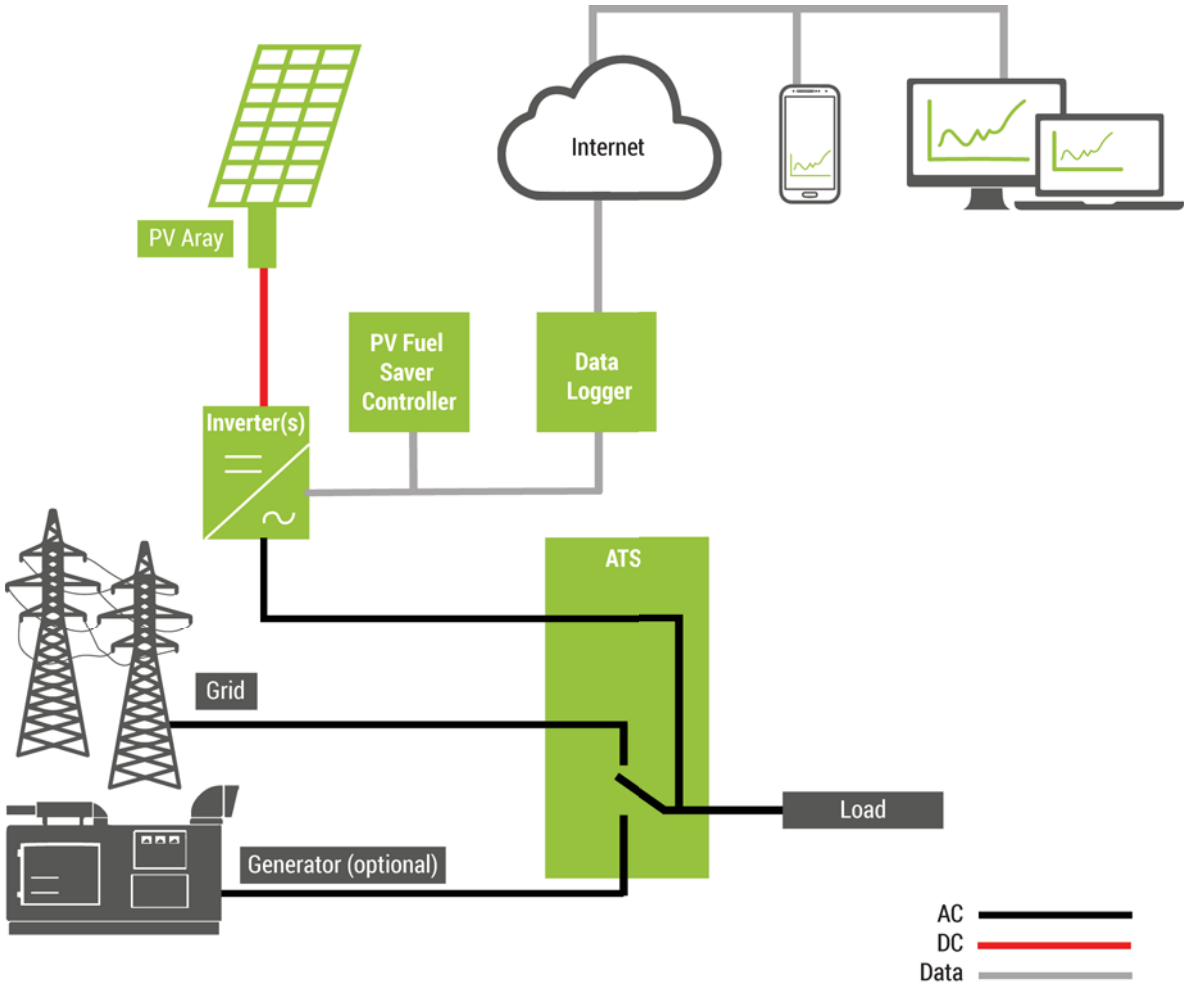
P151E

Solar FuelSaver™ Series

When installing solar in projects where back-up diesel power generators are available, it is necessary to implement a measure to reduce solar energy generation when the generators are operational in order to keep them running above their minimum load and avoid any reverse power.

In some projects and jurisdictions, the solar energy generated and fed back to the grid needs to also remain within a certain limit.

E24 FuelSaver Series allows to dynamically control the solar energy generated to keep the generators running at a present minimum level. It can also be used to also limit whenever needed the energy fed back to the grid from zero to any limit required.



Introduction

When installing solar PV System in projects where back-up diesel power generators are available, it is necessary to implement a measure to reduce solar energy generation when the generators are operational in order to keep them running above their minimum load and avoid any reverse power.

In some projects or some jurisdictions, the solar energy generated and fed back to the grid needs to also remain within a certain limit. E24 FuelSaver Series allows to dynamically control the solar energy generated to keep the generators running at a present minimum level. It can also be used to also limit - whenever needed - the energy fed back to the grid from 0 to any limit required.

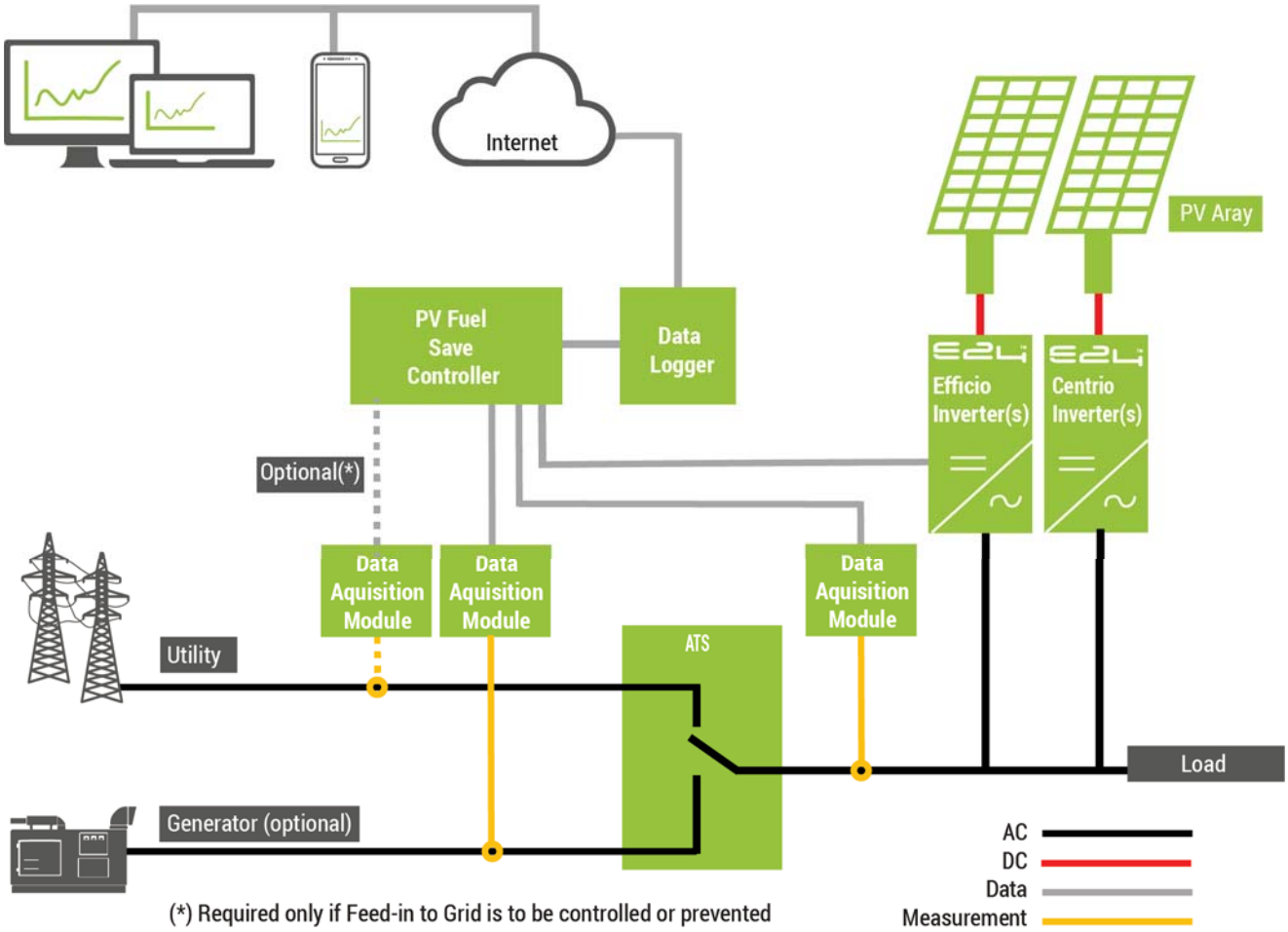
Together with E24 PV inverters, the E24 Fuel Save Controller offers a system solution for the integration of large-scale PV power plants into electrical networks based on fossil-fuelled power generation units (gensets) and limitation of reverse power fed-back to the grid whenever needed. The E24 Fuel Save Controller offers reliable control and monitoring of E24 PV inverters and allows a stable operation of the electrical network.

For this purpose, the E24 Fuel Save Controller permanently monitors the status of the gensets or utility source and the loads and adjusts the power output of the E24 PV inverters accordingly.

During the initial start-up, the system operator has the possibility to activate various functions for a stable and reliable system operation such as minimum genset or utility source loading and genset spinning reserve. In addition, it is possible to remotely monitor all relevant measurements, process data and the current system status via a SCADA system or a web-based user interface.

Primarily, the E24 Fuel Save Controller performs the following tasks:

- Monitoring of the gensets' power and operating status or utility power
- Monitoring of the load and grid status
- Calculation of suitable values for the maximum power output of the PV inverters according to defined parameter
- settings and the current status of gensets and load
- Control and communication interface to PV inverters
- Internal logging of all relevant system data
- Provision of relevant system data for local and remote monitoring
- Emergency shutdown of the PV inverters in case of a system malfunction



Description

The E24 Fuel Save Controller consists of two different module types. Each module type is designed to fulfil particular tasks. The PV Main Controller Module is the main control unit of the E24 Fuel Save Controller. The Data Acquisition Module is used to monitor the current load and the grid status. The different modules are interconnected via an RS485 communication line that allows the modules to be installed in different locations.

The PV Main Controller Module is the main control unit of the E24 Fuel Save Controller. It comprises monitoring of the gensets, logical control of the PV plant and an interface for local and remote monitoring. The PV Main Controller Module uses Modbus/TCP to communicate with up to twelve peripheral devices. Depending on the configuration, it is possible to communicate with the following devices:

- With up to five genset controllers or five Data Acquisition Modules for genset measurement
- With up to four Data Acquisition Modules for load measurement
- Up to twelve Centrio /Efficio Inverters
- With a remote monitoring system (SCADA or web interface/FTP)

The standard setup allows for the communication with up to five genset controllers, one Data Acquisition Module and one Efficio or Centrio inverter. In case of additional requirements, further equipment might need to be installed. The PV Main Controller Module monitors the gensets' operating state (online/offline) and their active and reactive power output via Modbus/TCP. For gensets without Modbus interface, it is alternatively possible to connect up to five Data Acquisition Modules to monitor up to five gensets. In combination with the system requirements defined during initial start-up and the information from load and grid measurements received from the Data Acquisition Module, the PV Main Controller Module calculates suitable maximum power values for the PV inverters (active and reactive power possible). These power values are communicated as setpoints to the Efficio or to the Centrio inverters. The PV Main Controller Module includes an interface for local and remote monitoring based on Modbus/TCP. For this purpose the PV Main Controller Module logs information about the inverter power and operating state, the load and the generator power and operating state in CSV format. The logged data is saved in five-second intervals for two days and as five-minute average value for 100 days and can be accessed by means of the integrated FTP server.

The Data Acquisition Module is an extension module to the PV Main Controller Module designed to acquire data from the electrical network or alternatively from gensets without Modbus interface. The Data Acquisition Module includes the measuring and data analysis electronics for a four-wire, three-phase grid connection. It measures voltage and current via external voltage and current transducers and calculates the current active and reactive power at the monitored metering point. The acquired data is transmitted to the PV Main Controller Module for further data processing.

Operation

Purpose of the E24 Fuel Save Controller

The E24 Fuel Save Controller has been designed to integrate E24 PV inverters into genset networks. The main purpose of the E24 Fuel Save Controller is to save fuel by substituting parts of the genset load with PV energy and to allow for a stable network operation at the same time. The PV plant can be regarded as a power generator operating in parallel with the gensets. As a supporting part of a genset network, it is mandatory to provide certain features related to power control, synchronisation and emergency operation. This can be assured with the installation of the E24 Fuel Save Controller combined with E24 PV inverters, even at a high PV penetration* of up to 60%. Nevertheless, the genset control system always remains the leading component of the network.

Operating Modes

The E24 Fuel Save Controller includes different operating modes that can be defined during system commissioning.

Operating Mode A
In operating mode A, the E24 Fuel Save Controller acts as the main control unit for the PV inverters. It permanently monitors the status and the power output of up to five gensets via a Modbus/TCP connection with the genset control units. Furthermore, it receives the acquired data for the load requirements and the grid status from the Data Acquisition Module and calculates a suitable setpoint for power output of the PV inverters under consideration of the conditions for the genset operation defined during initial start-up. These conditions are defined for each genset and include the following specifications: • Apparent power (kVA) • Active power (kW) • Activation threshold (kW) • Cut-out threshold (kW) • Minimum load (kW)

Operating Mode B
The principle of operating mode B is mostly identical to operation mode A. It applies if there is no possibility to communicate with the gensets via Modbus/TCP. In this case, up to five Data Acquisition Modules can be installed to monitor up to five gensets via voltage and current measurement. The operating data processing and the PV plant control works the same way as in operating mode A.

*Degree of penetration is the ratio (in per cent) of the total installed PV inverter power to the total maximum power of the gensets operated in parallel.

Features

The control strategy of the E24 Fuel Save Controller allows for permanently stable system operation. Therefore, the E24 Fuel Save Controller offers several features that can be activated as required. Those features affect the behavior of the E24 Fuel Save Controller and determine how it reacts in potentially critical scenarios or in operating states with optimizing potential.

Minimum Genset Loading

Most gensets should not be operated below a certain power level to avoid inefficient operation, internal glazing and reverse power scenarios. In times of high solar irradiation a 'generously dimensioned' PV plant could unload the gensets below this threshold. In those scenarios the E24 Fuel Save Controller reduces the power output of the PV inverters typically within five to seven seconds. The power adaptation rate is adjustable and can be modified if required.

Reverse Power Protection

If the E24 Fuel Save Controller detects a sudden load step (e.g. caused by load shedding or tripping of a protection device), the inverter power output is adjusted according to the defined power adaptation rate. In critical situations this might be too slow to avoid a genset reverse power scenario (the PV inverters feed power into the gensets). In this case the E24 Fuel Save Controller forces the immediate shut-down of the PV inverters. The complete inverter shut-down takes less than 2.5 seconds.

Spinning Reserve

To ensure stable operation, the E24 Fuel Save Controller makes sure that there is always sufficient spinning reserve available from the gensets to solely manage the load, e.g. in case of scattered cloud drift or sudden load changes. In genset networks with more than one unit, the E24 Fuel Save Controller can make use of the existing genset management functions like the genset activation and cut-out thresholds. In scenarios where the activation of an additional genset is mandatory to offer sufficient spinning reserve, the E24 Fuel Save Controller temporarily reduces the power output of the PV inverters. As a result the genset loading is raised above the activation threshold of another genset and the starting process can be engaged by the genset controller. In the opposite case it is possible to deactivate one unit if the remaining genset(s) still meet(s) the spinning reserve requirements. Thus, the E24 Fuel Save Controller temporarily allows for additional PV power to lower the genset loading in order to reach its cut-out threshold .

Inverter Power Adaptation Rate

The power adaptation rate of the PV inverter can have significant influence on the stability of a genset-based grid. Therefore, the E24 Fuel Save Controller allows the determination of the adaptation rate (ramp rate) of the PV inverter power output. This function only applies to controlled power adjustments and does not affect the 'natural' behavior of the inverter caused by changing solar irradiation conditions.

Reactive Power Management

Within a certain range E24 PV inverters are capable to support gensets with reactive power. By activating the reactive power management the E24 Fuel Save Controller creates a setpoint for the reactive power output of the PV inverters based on the current ratio of the active and reactive power demand. This leads to a lower reactive power loading of the gensets.

Micro-Grid Friendly

The feature "Micro-Grid Friendly" manages the behavior of the E24 Fuel Save Controller in systems that mainly rely on an electricity grid which uses gensets as a backup power supply. During power cuts the gensets supply the loads and can act as a reference for the PV inverters to synchronize to. When the electricity grid returns after a power cut, the E24 Fuel Save Controller temporarily reduces the power output of the PV inverters to an adjustable level to allow a smooth synchronisation of electricity grid and gensets. After the re synchronisation and connection process the inverter power output is increased again. The synchronisation process of gensets and grid is not controlled by the E24 Fuel Save Controller.

In this system configuration the grid monitoring of the PV inverters has to be adjusted according to the requirements of a genset-parallel operation. In some cases the required settings might not be accepted for grid-parallel operation. Therefore, permission of the local network operator is required.

Feed-In Protection (Optional)

The feature "Feed-In Protection" determines the behavior of the E24 Fuel Save Controller in systems supplied by an electricity grid or an electricity grid combined with backup gensets.

The purpose of this feature is to prevent the PV inverters from feeding into the electricity grid where this is not permitted. This feature is comparable with the generator minimum load feature and limits the power output of the PV inverters according to the defined minimum load of the electricity grid.

Influence of PV Inverters

PV inverters integrated in a genset-based network influence the grid parameters, especially voltage and frequency. This impact is very low in case of an PV penetration of 10% to 15% of the total rated apparent power of the gensets operated in parallel. The genset controller balances the influence caused by the inverters and maintains the grid stability. The impact level increases with higher PV penetration. If the PV penetration exceeds 20%, special control mechanisms, e.g. load-dependent frequency variation, have to limit the impact of the PV plant on the grid to avoid critical scenarios. Integrating the E24 Fuel Save Controller into a PV hybrid system ensures a stable system operation up to a PV penetration of 60%.

The E24 PV inverters act as a current source. This means that they always have to follow a reference grid. The inverters self-synchronize, permanently monitor the grid status and feed-in power as long as the grid voltage and frequency remain within a predefined range. In extreme situations the stability of the network has the highest priority. If voltage or frequency should exceed the accepted limits, the inverters switch off immediately and remain switched off as long as they register a violation of the accepted limits. This behavior allows a straight forward and safe integration of E24 PV inverters into the genset network.

In PV hybrid systems, E24 inverters react on the setpoints defined and transmitted by the E24 Fuel Save Controller with a varying power output. This is realized by a dynamic variation of the inverter operating point. The power output is continuously variable.

Standard PV inverters usually feed in pure active power into the grid. In some situations this can lead to disadvantageous genset operating states. Loads with high reactive power demand force the gensets to operate with an unfavorably low power factor. To reduce this effect and to support the generators to stabilise the system voltage, the PV inverters can be remotely controlled to compensate a certain amount of reactive power. Efficio string inverters can be operated with a minimum power factor of 0.8, Centrio inverters with 0.9, both overexcited and underexcited. The power factor of the inverter is electronically controlled, can be changed without any delay and has no negative impact on the inverter.

Technical Specifications

PV Main Controller Module

Mechanical Data

Width x height x depth	600 mm x 800 mm x 210 mm
Weight	30 kg
Degree of protection according to IEC 60529	IP65

Climatic Requirements

Operating temperature	–10°C to +50°C
Humidity, non-condensing	5% to 95%
Maximum installation height above MSL	2,000 m

Voltage Supply

Voltage	110 V to 240 V
Frequency	50 Hz to 60 Hz
Maximum power	200 VA
Maximum back-up fuse	Miniature circuit-breaker 10 A, type B
Type of connection	Spring clamp terminal
Conductor cross-section	1.5 mm² to 2.5 mm²

Communication

Communication E24 Fuel Save Controller with power plant control, SCADA and remote monitoring	Modbus/TCP, HTTP, FTP via Ethernet 10 BASE-T, Ethernet 100 BASE-T(X)
Communication between the modules	Ethernet 100 BASE-FX or Ethernet 100 BASE-TX
Communication with Efficio Inverters	Speedwire, 10/100 Mbit/s
Communication with Centrio Inverters	Ethernet, 100 BASE-FX or 100 BASE-TX**
Communication with genset Control	Modbus/TCP via Ethernet 10 BASE-T or Ethernet 100 BASE-T (X)
Type of connection for Ethernet BASE-T(X)	RJ45
Type of Connection for Ethertnet BASE-FX	SC

Multifunctional Switching Inputs

Number	8
Terminal voltage at 0 mA	24 V
Maximum voltage drop at 10 mA	5 V
Connectable switches	Potential-free switches
Type of connection	Spring clamp terminal
Conductor cross-section	1.5 mm² to 2.5 mm²

Multifunctional Switching Outputs

Number	4
Terminal voltage	Potential-free
Maximum of connectable switching voltage	250 V
Maximum signal current	6 A
Type of connection	Spring clamp terminal
Conductor cross-section	1.5 mm² to 2.5 mm²

Visualisation/Web Interface

Visualisation and configuration interface	Ethernet interface for a Touch Panel or internet browser
Access to visualisation and configuration interface	Local or remote
Recording of measured values	Inst. values every 5s and mean values every 5 min.
Real-time visualisation of predefined values	Yes
Recording of events	Logbook
Access to data	Via the integrated FTP server

Compatibility

Compatibility with PV inverters	E24 Efficio and Centrio Series
Maximum degree of penetration*	60%
Maximum number of handled gensets	5

*Degree of penetration is the ratio (in per cent) of the total installed PV inverter power to the total maximum power of the gensets operated in parallel.

Data Acquisistion Module

Mechanical Data

Width x height x depth	600 mm x 600 mm x 210 mm
Weight	30 kg
Degree of protection according to IEC 60529	IP65

Climatic Requirements

Operating temperature	−10°C to +50°C
Humidity, non-condensing	5% to 95%
Maximum installation height above MSL	2,000 m

Voltage Supply

Voltage	110 V to 240 V
Frequency	50 Hz to 60 Hz
Maximum power	200 VA
Maximum back-up fuse	Miniature circuit-breaker 10 A, type B
Type of connection	Spring clamp terminal
Conductor cross-section	1.5 mm² to 2.5 mm²

Communication

Communication between the modules	Ethernet 100 BASE-FX or Ethernet 100 BASE-TX
Type of connection for Ethernet BASE-T(X)	RJ45
Type of connection for Ethernet BASE-FX	SC

Multifunctional Switching Inputs

Number	2
Terminal voltage at 0 mA	24 V
Maximum voltage drop at 10 mA	5 V
Connectable switches	Potential-free switches
Type of connection	Spring clamp terminal
Conductor cross-section	1.5 mm² to 2.5 mm²

Switching Output of the Overvoltage Protection

Number	1
Terminal voltage	Potential-free
Maximum of connectable signal voltage	250 V
Maximum AC signal current	0.5 A
Maximum DC signal current	0.1 A
Type of connection	Spring clamp terminal
Conductor cross-section	1.5 mm² to 2.5 mm²

Measurement Inputs

Number of voltage measuring inputs	4
Measurement range of the voltage between phase and neutral	0 V to 300 Vrms
Measurement range of the voltage between phase and phase	0 V to 415 Vrms
Resolution of voltage measurement	10 mV
Impedance	4 MΩ per phase conductor
Number of current measuring inputs	4
Current measurement range	0 A to 5 A
Resolution of current measurement	1 mA
Type of connection	Spring clamp terminal
Conductor cross-section	1.5 mm² to 2.5 mm²

PV Panels

PV Cabling Kits

PV Mounting Kits

PV Charge Controllers

PV Inverter

PV Controllers

E24 Modular Range Of Solar Products For Building Easy, Flexible & Evolutive Solutions

E24 products dynamically evolve with the lifestyle and work style of its customers while easing the installation process.

E24 products are conceived in modules allowing for an easy upgrade to adjust with the needs of the customers. Being modular and easy to connect E24 products allow installers to easily configure the required modules for an optimal solution while offering easy upgrade options.

Ordering Information

Ref Number	Description
PVFS3-3	Fuel Save Controller for up to 5 Genset controllers with up to 6 Data Acquisition Modules to Control up to 3 inverters
PVFS3-5	Fuel Save Controller for up to 5 Genset controllers with up to 7 Data Acquisition Modules to Control up to 5 inverters
PVFS3-8	Fuel Save Controller for up to 5 Genset controllers with up to 8 Data Acquisition Modules to Control up to 8 inverters
PVFS3-12	Fuel Save Controller for up to 5 Genset controllers with up to 9 Data Acquisition Modules to Control up to 12 inverters
PVFS-DAM	Fuel Save Data Acquisition Module

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ISO 9001:2015

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