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1 PV power plant.

2 PV battery charger with 2 MPP trackers, buck-boost topology and 1,000 V output.

## POWER ELECTRONICS FOR OFF-GRID SYSTEMS

Many reports and studies published in the last few years have shown that more than 1.2 billion people worldwide do not have access to electricity. Most live in remote areas, where extending the grid is not economically feasible.

Furthermore, power costs from fossil fuel continue to increase whereas the cost of renewables is falling. PV systems in particular are becoming more affordable, mainly driven by the steadily falling prices of PV modules. As a consequence, there is clearly potential for PV, wind, hydro and biomass in off-grid power supply systems.

Our experience in the field of power electronics is combined with more than 30 years of knowledge in remote PV hybrid systems. We develop efficient and flexible power converters for all kinds of remote applications. One significant project dates back to 1987: it was the integration of a PV generator, a wind generator, a lead-acid battery and a fuel cell at a

remote mountain hut in the Black Forest. This system still is operating today. One of our recent activities in off-grid power electronics was the development of a large-scale, high-power remote village supply system. For its innovative character and impressive results, the project received the Semikron Innovation Award in 2013.

### Special Lab Equipment

- 15 kWp roof-mounted PV generator
- 30 kW three-phase grid simulator
- 128 kW DC source / PV simulator
- 128 kW bidirectional DC source
- cell / battery simulator
- battery and super-cap banks
- high-precision power analyzers
- 110 kW roof-mounted dump load
- EMC test equipment
- burst and surge generators
- high-resolution thermography equipment
- development environments for  $\mu$ C, DSP and FPGA
- numerous simulation software

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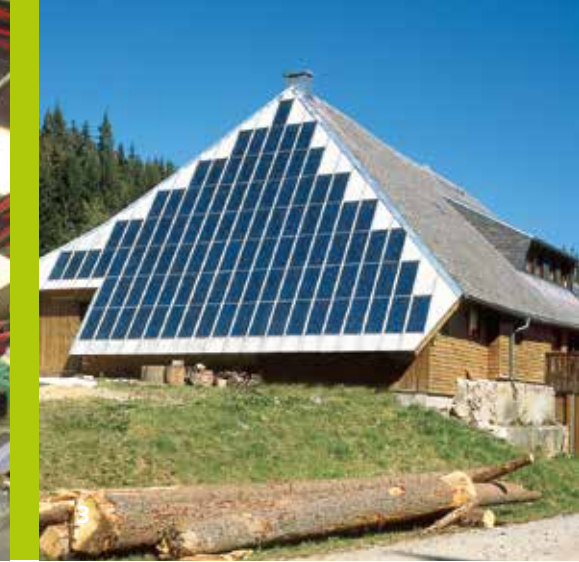
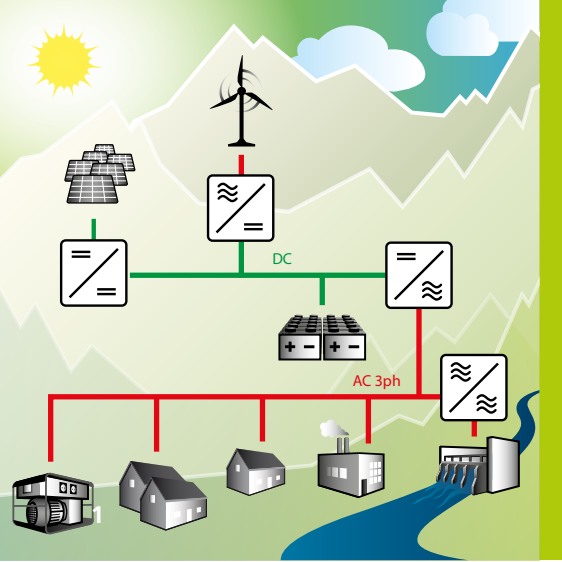
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### Off-Grid PV Inverters

The centerpiece of every PV off-grid system is a stand-alone inverter. We offer our clients and partners extensive knowledge of highly efficient, dynamic, versatile and cost effective off-grid inverters. Also, we put lots of effort in the adaptation of the latest technologies and technological approaches to the specific needs of the off-grid market.

### Off-Grid PV Battery Chargers

To increase the security of electrical power supply during bad weather conditions and at night, energy storage is an essential component of any off-grid PV system. Due to the wide variety of storage technologies – such as lead-acid, lithium and redox-flow batteries – individual charger designs are mandatory. Indeed, commercial devices rarely offer the right input and output voltage, the desired power and conversion efficiency and the needed control and charging behavior.

### Power Electronics for Hybrid Systems

The largest share of worldwide off-grid systems is powered by diesel generator sets. These systems often run at low efficiency and emit large quantities of CO<sub>2</sub>. When diesel subsidies are reduced, their operating costs increase dramatically. Moving to more efficient systems with low capital expenditures and a fast return on investments automatically leads to the integration of PV. The switch saves fuel and reduces the on-time of combustion engines, not to mention pollution. We support our clients and partners with all required knowledge to extend and upgrade running systems.

### Customized Circuit Design

For any new circuit design, customer-oriented discussions are mandatory. In-house standards are analyzed in detail and ambitious project milestones are defined. Innovative ideas are discussed with the aim of turning them into a successful product. Along with our clients and partners, our experienced engineers find the optimum circuits and controllers to fulfill all technical requirements and specifications.

### Power Electronics Development

Once the main circuit design is defined, hardware experts work out the technical details for the active stage, design passive components and filters, develop a cooling solution, elaborate all other electronic subassemblies, and determine the electrical wiring needed for the final device. We use calculation, simulation and device-oriented design programs – such as Mathcad®, PLECS®, FloTHERM® and Altium Designer – to develop high-quality designs.

### Analog and Digital Control Design

Our qualified software engineers develop professional approaches for analog and digital controls of advanced power electronics circuits. A unique and detailed simulation model based on MATLAB® / Simulink® and PLECS® allows the controllers to be tested so we can verify that they fulfil all applicable norms and specifications. Customized control boards with different processors, extended peripheral units and particular timing concepts can be developed to best fit to the application.

### Building up Prototypes

Because the quality of a design is not fully demonstrated until the device works in reality, our qualified technicians regularly engineer small series of prototypes. Our group puts emphasis on approaching the end product as much as possible to avoid intermediate stages. We work out electrical schematics, design Printed Circuit Boards (PCB) and build up devices with peripheral components. After debugging, the device is verified in compliance with the specifications.

We also provide support in the following fields:

- power electronics for water pumping, treatment and desalination applications
- design of micro-grids and parallel operation of multiple inverters
- control theory for weak power grids and grid connection of off-grid systems

- 1 *Remote village power supply.*
- 2 *Test of multi-level high power modules for a new generation of off-grid inverter.*
- 3 *Rappenecker Hütte, still running 30-year-old off-grid system in the Black Forest, Germany.*