Products and solutions for solar energy

STMicroelectronics

From the sun to the grid

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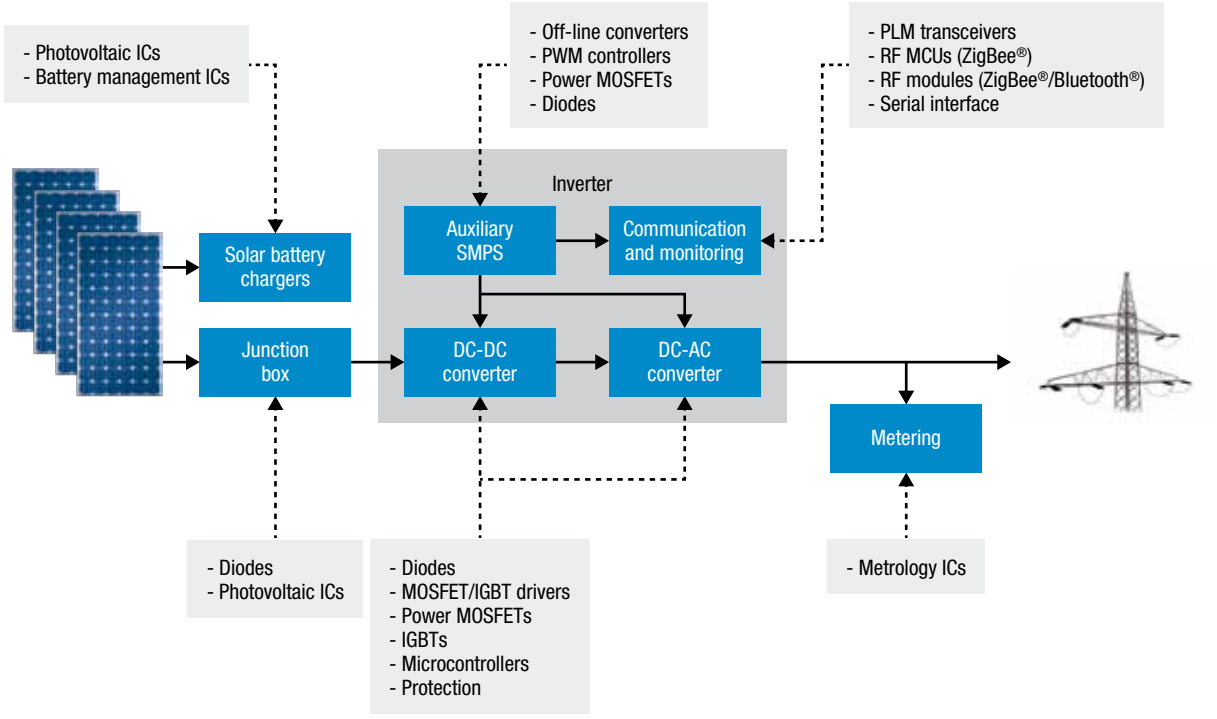
Introduction

ST's range of new products and solutions dedicated specifically to the photovoltaic world demonstrates our commitment to providing smarter solutions for the needs of the solar energy market. The diagram below shows the full extent of ST's involvement in the photovoltaic world.

ST positioning in the photovoltaic world

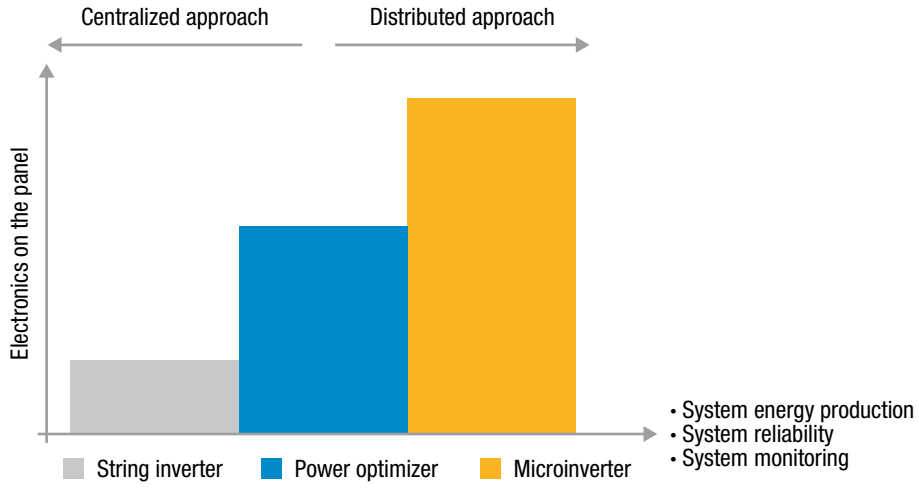


ST's innovative solar devices implement the MPPT (maximum power point tracking) algorithm to maximize the energy produced from each solar panel at any panel temperature and radiation condition and so to maximize the overall efficiency of the PV system.

ST provides semiconductor devices with high performance and high efficiency for every solar application. This brochure presents our products and solutions for photovoltaic applications, for the major grid-tied architectures and for solar battery applications.

Photovoltaic grid-connected system architectures

The traditional grid-tied architecture of photovoltaic systems concentrates all the electronics in the central inverter. This is the centralized approach. To gain in terms of global system energy production, reliability, safety, communication and monitoring, the trend today is to move towards the distributed approach where the electronics is partially or fully distributed close to each panel.



The following three photovoltaic grid-tied architectures are analyzed here:

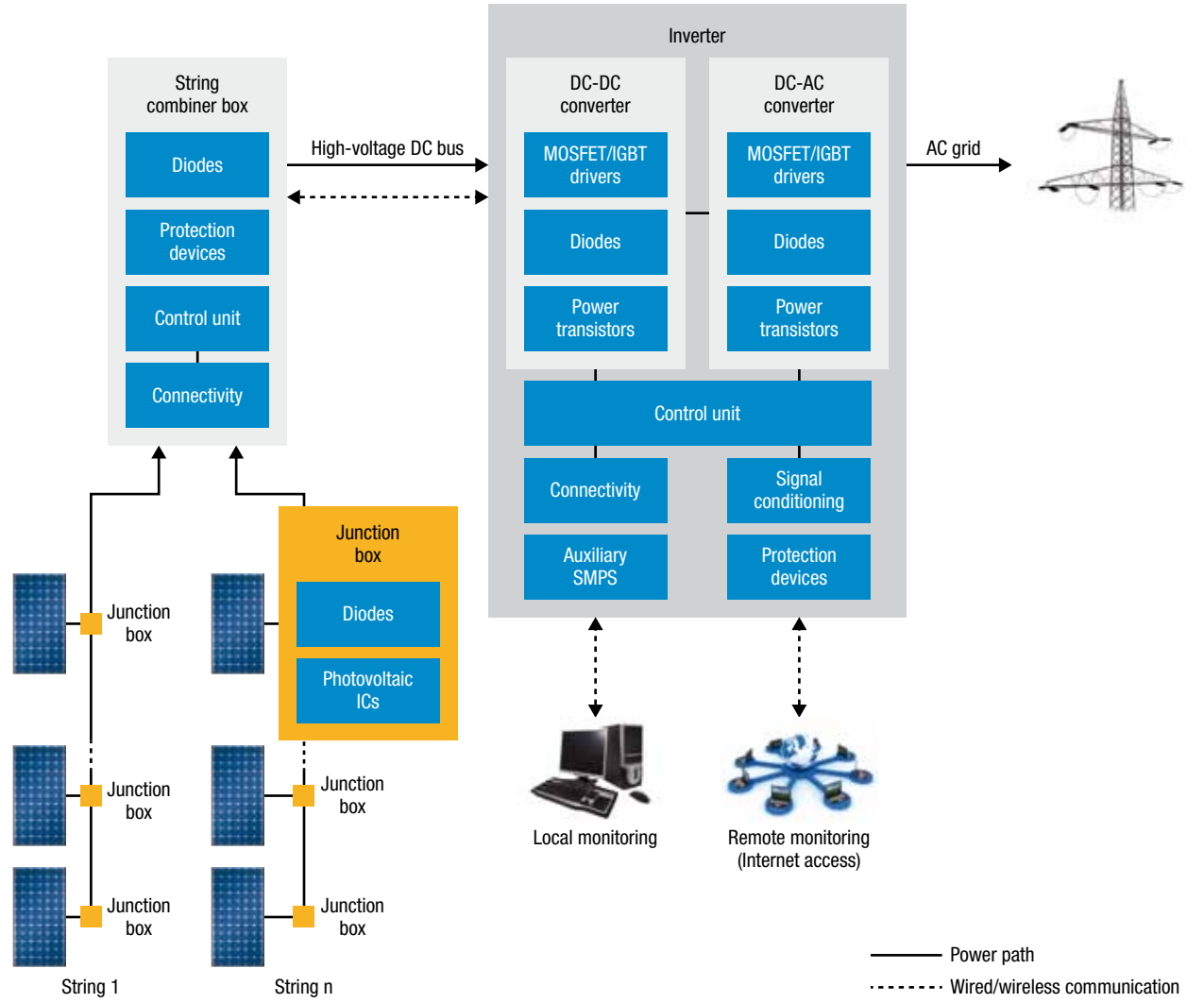
- String and central inverter based architectures (centralized approach)
- Power optimizer based architectures (partially distributed approach)
- Microinverter based architectures (fully distributed approach)

String and central inverter based architectures

String and central inverter based architectures represent the most common power conversion system for grid-connected applications (Figure 1). It is composed of three main functional blocks.

- **The junction box**, present in each solar panel, provides the key bypass functionality (preventing hot-spot phenomena caused by reverse biasing due to defective cells or shading). In the junction box, the bypass device is connected in antiparallel to the solar panel. To optimize panel energy production, generally one bypass device is connected in antiparallel to each of the three cell strings in which the panel is divided. Bypass functionality may be implemented using one of the following device families:
  - Bypass diodes
  - Photovoltaic ICs
- **The string combiner box** provides the protection and monitors the solar panel strings.
- **The inverter** provides the MPPT to adapt the impedance that the panel sees at its output to obtain maximum power transfer, the DC-DC power conversion stage to adapt voltage levels and the DC-AC power conversion stage to correctly shape the current and voltage waveforms and to connect to the AC grid. Power range varies from a few kilowatts to tens of kilowatts depending on the size of the solar system.

Figure 1 Block diagram of a string and central inverter based architecture



ST's product offering for the central inverter architecture is shown below. The key products for each functional block described above are described in the table below.

Product offering for string and central inverter based architectures

Functional block	Product type	Key products	Description
Junction boxes	**Photovoltaic ICs**	SPV100*	Cool bypass switches
	Diodes	STPS*30, STPS*45	30/45 V power Schottky diodes
Inverters (DC-DC and DC-AC)	**Control units**	STM32F103 STM32F107 STM32 F2 STM32 F4	32-bit ARM Cortex MCUs: - STM32 F1 Mainstream family - STM32 F2 High-performance family - STM32 F4 Hi-Performance & DSP
	MOSFET/IGBT drivers	TD350, TD351, TD352	Advanced gate drivers for IGBT and power MOSFETs
		PM883*	High-frequency dual low-side driver for high-capacitive MOSFETs and IGBTs
		L638*, L639*	Gate drivers with half-bridge driver structure for IGBTs and power MOSFETs
	Power transistors	STW88N65M5 STY139N65M5	650 V N-channel power MOSFETs, MDmesh™ V technology - TO-247 package - Max247 package
		STW*NM*ND	600/650 V N-channel power MOSFET, FDmesh™ II technology
		STY100NM60N STW62NM60N	600 V N-channel power MOSFETs, MDmesh™ II technology - Max247 package - TO-247 package

Functional block	Product type	Key products	Description
Inverters (DC-DC and DC-AC)	**Power transistors**	STGW60H65DRF STGW25H120DF	650/1200 V field stop trench gate IGBT with ultrafast diodes
		STGW50HF60SD STGW*HF60WD	600 V IGBT with ultrafast diode: - SD series, very low drop IGBT (ideal in low-frequency switches of mixed-frequency topologies) - WD series based on a new advanced planar technology (tailored for high switching frequencies, over 100 kHz)
	Diodes	STTH*BC	600/650 V high-voltage rectifiers for BC^2 topology
		STTH*06	600 V ultrafast high-voltage rectifiers, Turbo2 technology
		STTH*10	1000 V ultrafast high-voltage diodes
		STPSC*06	600 V silicon-carbide diodes
	Auxiliary power supplies	VIPer*7	High-performance off-line high-voltage converters
		ST*N150	1500 V N-channel power MOSFETs, PowerMESH™ technology
		ST*6N120K3	1200 V N-channel power MOSFETs in Zener protected SuperMESH™3
		STPS*L40 STPS*150	40/150 V power Schottky diodes
		STTH*L06	600 V ultrafast high-voltage rectifiers, Turbo2 technology, with a low Vf trade-off
		P6KE, 1.5KE	600/1500 W Transil™ transient voltage suppressors
		TS43*	Low-voltage adjustable shunt references
		TL43*	Programmable voltage references
	Protection devices	SMBJ, BZW50	600 W/ 5 kW Transil™ transient voltage suppressors
		STIEC45	500 A power line surge current protection
	Signal conditioning	TS43*	Low voltage adjustable shunt reference
		TL43*	Programmable voltage references
		TS95*	Operational amplifiers
	Connectivity	STM32W108	32-bit RF(Zigbee®) microcontrollers
		SPZB32W1x2.1	ZigBee® modules (ready-to-use) based on ST's STM32W108CB
		SPBT2532	Bluetooth® module
		ST75*0	Power line transceivers (STarGRID™ family)
		ST3232	3 V powered EIA/TIA-232 and V.28/V.24 communication interface with low power requirements
		ST485	5 V low-power, high-speed transceiver for RS-485 and RS-422 communications with ESD protection
		ST3485	3.3 V low-power transceiver for RS-485 and RS-422 communications with ESD protection
		ST802RT	10/100 real-time Ethernet 3.3 V transceiver
		SMP	Trisil™ thyristor surge suppressors to protect high data rate communication equipment
		SM6T, SM15T	600/1500 W Transil™ transient voltage suppressors
String combiner boxes	**Control unit**	STM32F103	32-bit ARM Cortex MCUs, STM32 F1 Mainstream family
	Diodes	STTH*06	600 V ultrafast high-voltage rectifiers, Turbo2 technology
		STTH*10	1000 V ultrafast high-voltage diodes
	Protection devices	SMBJ, BZW50	600 W/5 kW Transil™ transient voltage suppressors
		STIEC45	500 A power line surge current protection
	Connectivity	STM32W108	32-bit RF (ZigBee®) MCUs
		SPZB32W1x2.1	ZigBee® modules (ready-to-use) based on ST's STM32W108CB
		ST75*0	Power line transceivers (STarGRID™ family)
		ST3232	3 V powered EIA/TIA-232 and V.28/V.24 communication interface, low power, high data-rate capabilities
		ST485	5 V low-power, high-speed transceivers for RS-485 and RS-422 communications with ESD protection
		ST3485	3.3 V low-power transceivers for RS-485 and RS-422 communications with ESD protection
		ST802RT	10/100 real-time Ethernet 3.3 V transceiver
		SMP	Trisil™ thyristor surge suppressors to protect high data rate communication equipment
		SM6T, SM15T	600/1500 W Transil™ transient voltage suppressors

ST's evaluation boards designed for the central inverter based architecture are shown below.

Evaluation boards for string and central inverter architectures

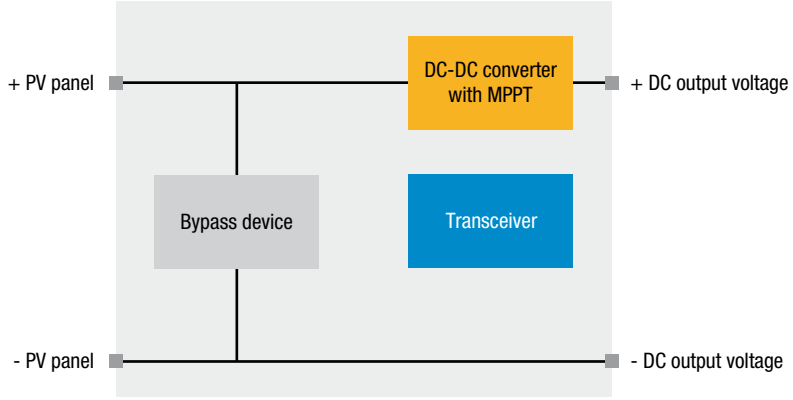
Sales code	Board	Description	Technical documentation
STEVAL-ISV001V1		1 kW inverter for UPS or for standalone systems	AN2794
STEVAL-ISV002V2		3 kW PV converter for grid-connected applications	UM1016 AN3095

Power optimizer based architectures

Architectures based on power optimizers represent partially distributed photovoltaic grid-connected systems (Figures 3 and 4) where part of the electronics from a central or string inverter is moved close to each panel. This architecture includes three main functional blocks.

- **The power optimizer** is a smart system (Figure 2) that combines the MPPT and DC-DC power conversion with connectivity capabilities at the photovoltaic panel.

Figure 2 Power optimizer (simplified block diagram)



Using the distributed MPPT, each panel operates at its maximum power point and so the overall efficiency of the whole photovoltaic system is increased compared to a traditional string or central inverter based architecture. The module-level communications and real-time monitoring features allow the power optimizer to improve system reliability and safety and to reduce system maintenance costs.

Two different architectures based on the power optimizer can be implemented depending on the output voltage of the DC-DC converter.

Low-voltage power optimizer based architecture:
Low-voltage power optimizers are an evolution of existing solar-panel junction boxes. They add a low output voltage DC-DC converter with MPPT functionality and a smart connectivity capability to the bypass function. In this architectures the PV array is configured as in string or central inverter based architectures so the PV panels continue to be wired serially in strings (Figure 3).

High-voltage power optimizer based architecture:
High-voltage power optimizers feature a DC-DC converter output voltage high enough to allow a direct connection to the main inverter. In this case, the power optimizers, and so the PV panels, can be wired in parallel (no serial connection is needed) resulting in a simplified configuration for the photovoltaic system (Figure 4).

- **The inverter** provides only the DC-AC power conversion and the connection to the AC grid.
- **The data concentrator** collects the data (voltage values, current values, etc.) coming from all the panels and from the inverter and sends them to a local or remote monitoring and control access point.

The benefits of power optimizer based architectures are:

- More energy production: the distributed MPPT at panel level guarantees the maximization of system energy production
- Smart communication and monitoring capabilities for each panel
- Greater reliability: with the high-voltage architecture, failure of one power optimizer does not affect the system energy production

Figure 3 Low-voltage power optimizer based architecture (simplified block diagram)

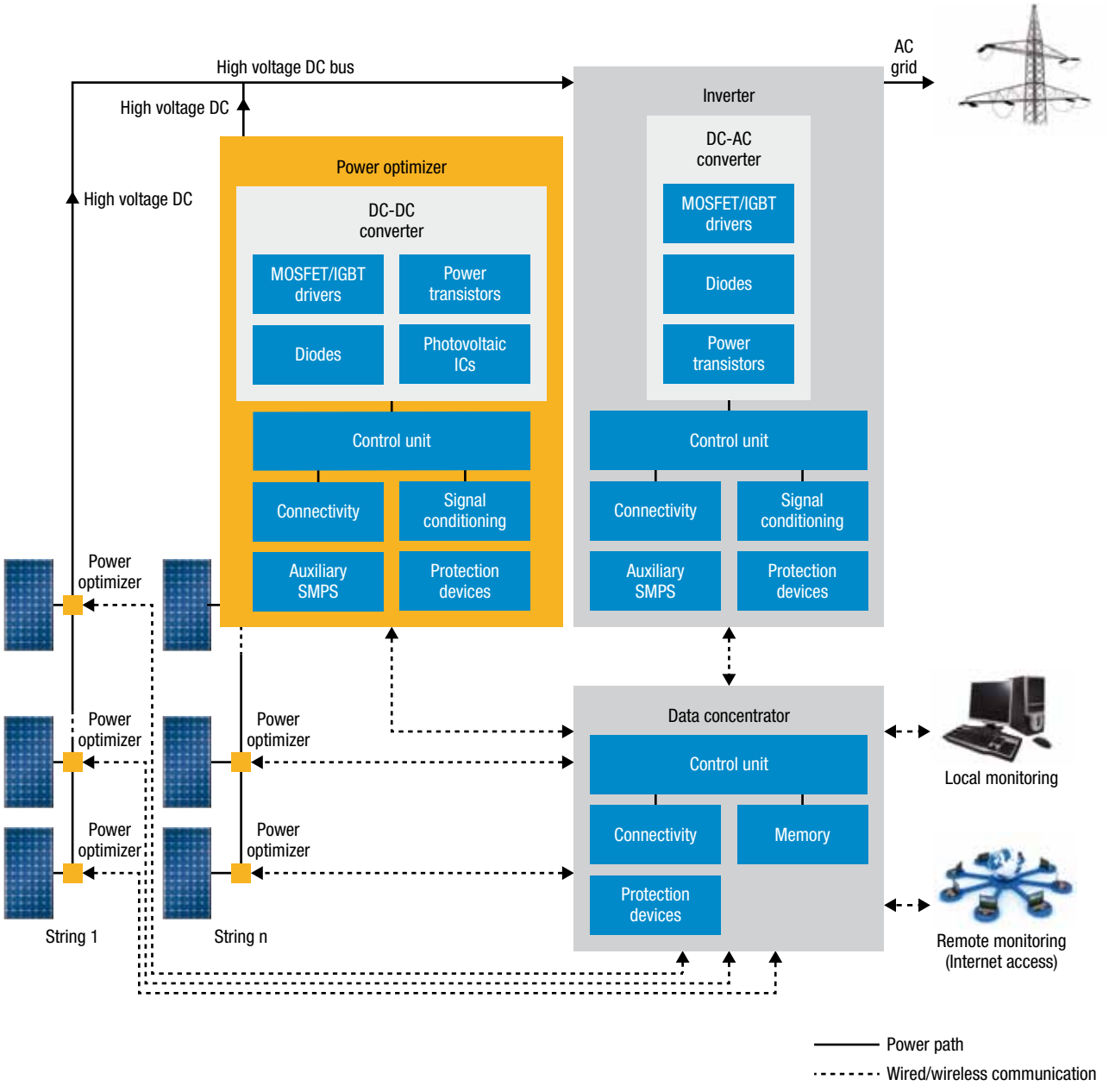
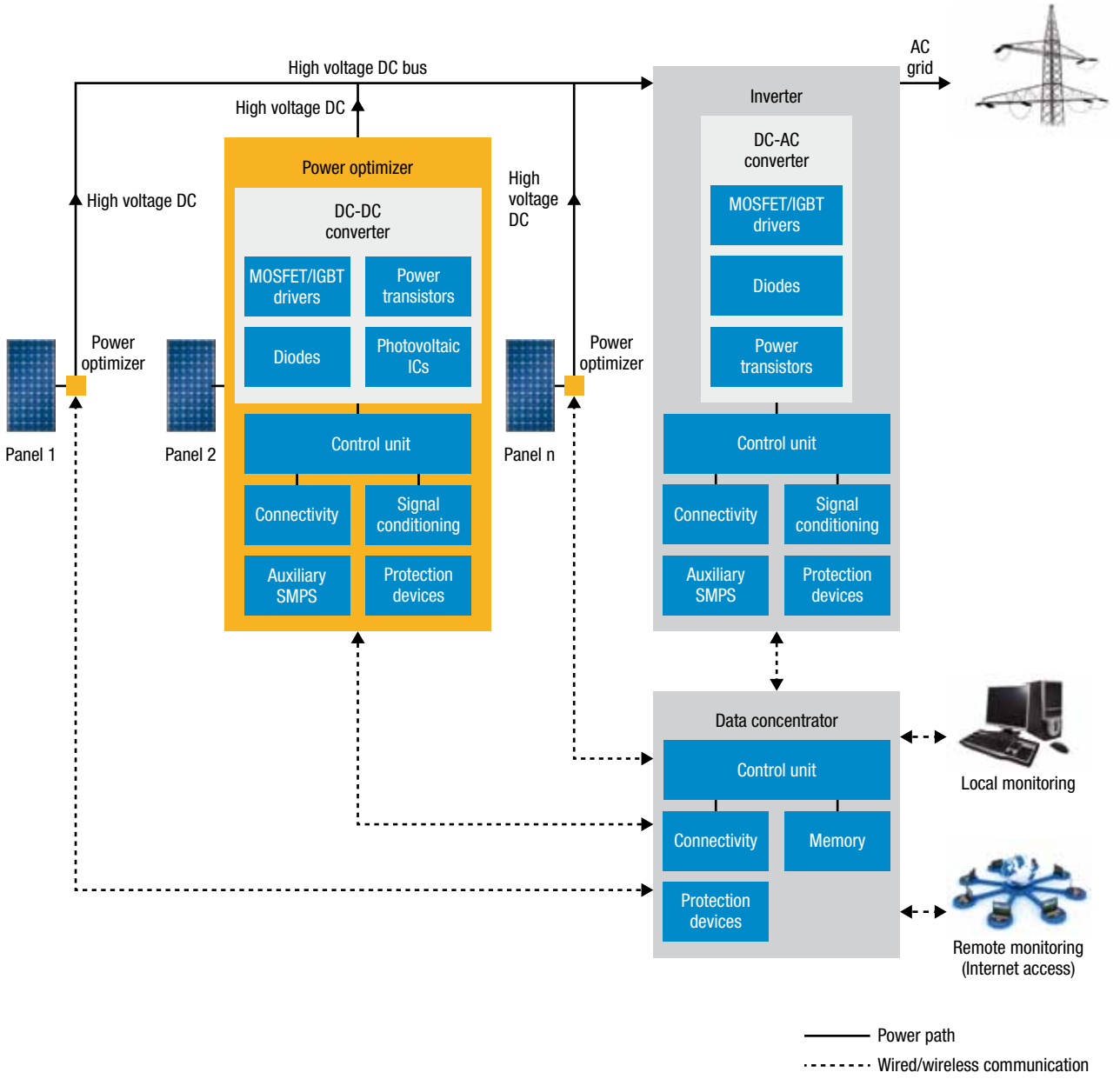


Figure 4 High-voltage power optimizer based architecture (simplified block diagram)



ST's product offering for power optimizer architecture is shown below. The key products for each functional block described above are described in the table below.

Product offering for power optimizer based architectures

Functional block	Product family	Key products	Description
Power optimizers	**Photovoltaic ICs**	SPV100*	Cool bypass switches
		SPV1020	Interleaved DC-DC boost converter with built-in MPPT algorithm
	Diodes	STPS*45 STPS*60	45/60 V power Schottky rectifiers
		STTH*06	600 V ultrafast high-voltage rectifiers, Turbo2 technology
		STPSC*06	600 V silicon-carbide diodes
		STTH*BC	600/650 V high-voltage rectifier for BC2 topology
	Control units	STM32F103 STM32F107 STM32 F2 STM32 F4	32-bit ARM Cortex MCUs: - STM32 F1 Mainstream family - STM32 F2 High-performance family - STM32 F4 Hi-Performance & DSP
	MOSFET/IGBT drivers	TD350, TD351, TD352	Advanced gate drivers for IGBTs and power MOSFETs
		PM883*	High-frequency dual low-side driver for high-capacitive MOSFETs and IGBTs
		L638*, L639*	Gate drivers with half-bridge driver structure for IGBTs and power MOSFETs
	Power transistors	STL70N10F3 STH130N10F3-2 STH180N10F3-2	100 V N-channel power MOSFETs, in STripFET™ III technology - PowerFLAT™ 5x6 package - TO220FP and H²PAK-2 packages - H²PAK-2 package
		STH310N10F7-2	100 V N-channel power MOSFET in STripFET™ VII DeepGATE™ technology
	Auxiliary power supplies	Viper*7	High-performance off-line high-voltage converter
		STPS*L60, STPS*H100	60/100 V power Schottky rectifiers
		STTH*06	600 V ultrafast high-voltage rectifiers, Turbo2 technology
		STD20NF20	200 V N-channel power MOSFET in STripFET™ technology
		P6KE, 1.5KE	600/1500 W Transil™, transient voltage suppressors
		TS72*	Micropower comparators
	Protection devices	SMBJ, BZW50	600 W/5 kW Transil™ transient voltage suppressors
		STIEC45	500 A power line surge current protection
	Signal conditioning	TS50*, TS51*, TS52*,TS91*	Operational amplifiers
		STG5*	Analog switches
	Connectivity	STM32W108	32-bit RF (ZigBee®) MCUs
		SPZB32W1x2.1	ZigBee® modules (ready-to-use) based on ST's STM32W108CB
		ST75*0	Power line transceivers (STarGRID™ family)
		ST3232	3 V powered EIA/TIA-232 and V.28/V.24 communication interface, low power, high data-rate capabilities
		ST485	3.3 V low-power, high-speed transceiver for RS-485 and RS-422 communications with ESD protection
		ST3485	5 V low-power transceiver for RS-485 and RS-422 communications with ESD protection
		ST802RT	10/100 real-time Ethernet 3.3 V transceiver
		SMP	Trisil™ thyristor surge suppressors to protect high data rate communication equipment
		SM6T, SM15T	600/1500 W Transil™ transient voltage suppressors
Inverters (DC-AC)	**Control units**	STM32F103 STM32F107 STM32 F2 STM32 F4	32-bit ARM Cortex MCUs: - STM32 F1 Mainstream family - STM32 F2 High-performance family - STM32 F4 Hi-Performance & DSP
	MOSFET/IGBT drivers	TD350, TD351, TD352	Advanced gate drivers for IGBTs and power MOSFETs
		PM883*	High-frequency dual low-side drivers for high-capacitive MOSFETs and IGBTs
		L638*, L639*	Gate drivers with half-bridge driver structure for IGBTs and power MOSFETs
	Power transistors	STW88N65M5 STY139N65M5	650 V N-channel power MOSFET, MDmesh™ V technology - TO-247 package - Max247 package
		STW*NM*ND	600/650 V N-channel power MOSFETs, FDmesh™ II technology
		STY100NM60N STW62NM60N	600V N-channel power MOSFETs MDmesh TM II technology - Max247 package - TO-247 package
		STGW60H65DRF STGW25H120DF	650/1200 V field stop trench gate IGBTs with ultrafast diodes

Product offering for power optimizer based architectures (cont'd)

Functional block	Product family	Key products	Description
Inverters (DC-AC)	**Power transistors**	STGW50HF60SD	600 V ultrafast IGBTs with ultrafast diode - SD series, very low drop IGBT (ideal in low-frequency switches of mixed-frequency topologies)
		STGW*HF60WD	- WD series based on a new advanced planar technology (tailored for high switching frequencies, over 100 kHz)
	Diodes	STTH*10	1000 V ultrafast high-voltage diodes
		STTH*06	600 V ultrafast high-voltage rectifiers, Turbo2 technology
		STPSC*06	600 V silicon-carbide diodes
	Auxiliary power supplies	Viper*7	High-performance off-line high-voltage converters
		ST*N150	1500 V N-channel power MOSFETs, PowerMESH™ technology
		ST*6N120K3	1200 V N-channel power MOSFETs in Zener protected SuperMESH™3
		STPS*L40 STPS*150	40/150 V power Schottky rectifiers
		STTH*L06	600 V ultrafast high-voltage rectifiers, Turbo2 technology with a low Vf trade-off
		P6KE, 1.5KE	600/1500 W Transil™ transient voltage suppressors
		TS43*	Low-voltage adjustable shunt references
		TL43*	Programmable voltage references
	Protection devices	SMBJ, BZW50	600 W/5 kW Transil™ transient voltage suppressors
		STIEC45	500 A power line surge current protection
	Signal conditioning	TS43*	Low-voltage adjustable shunt references
		TL43*	Programmable voltage references
		TS95*	Operational amplifiers
	Connectivity	STM32W108	32-bit RF (ZigBee®) MCUs
		SPZB32W1x2.1	ZigBee® modules (ready-to-use) based on ST's STM32W108CB
		ST75*0	Power line transceivers (STarGRID™ family)
		ST3232	3 V powered EIA/TIA-232 and V.28/V.24 communication interface, low power, high data-rate capabilities
		ST485	5 V low-power, high-speed transceivers for RS-485 and RS-422 communications with ESD protection
		ST3485	3.3 V low-power transceivers for RS-485 and RS-422 communications with ESD protection
		ST802RT	10/100 real-time Ethernet 3.3 V transceiver
		SMP	Trisil™ thyristor surge suppressor to protect high data rate communication equipment
		SM6T, SM15T	600/1500 W Transil™ transient voltage suppressors
Data concentrators	**Control units**	STM32F103 STM32F107 STM32 F2 STM32 F4	32-bit ARM Cortex MCUs: - STM32 F1 Mainstream family - STM32 F2 High-performance family - STM32 F4 Hi-Performance & DSP
	Memories	M24C, M241, M242, M245, M24M, M93 M95	EEPROM serial memories
		M24LR	RF-I²C Dual Interface EEPROM memories
	Connectivity	STM32W108	32-bit RF (ZigBee®) MCUs
		SPZB32W1x2.1	ZigBee® modules (ready-to-use) based on ST's STM32W108CB
		ST75*0	Power line transceivers (STarGRID™ family)
		SPBT2532	Bluetooth® module
		ST3232	3 V powered EIA/TIA-232 and V.28/V.24 communication interface, low power, high data-rate capabilities
		ST485	5 V low-power, high-speed transceivers for RS-485 and RS-422 communications with ESD protection
		ST3485	3.3 V low-power transceiver for RS-485 and RS-422 communications with ESD protection
		ST802RT	10/100 real-time Ethernet 3.3 V transceiver
		SMP	Trisil™ thyristor surge suppressor to protect high data rate communication equipment
		SM6T, SM15T	600/1500 W Transil™ transient voltage suppressors
	Protection devices	SMBJ, BZW50	600 W/5 kW Transil™ transient voltage suppressors
		STIEC45	500 A power line surge current protection

ST's evaluation boards designed for the power optimizer based architecture are shown below.

Evaluation boards for power optimizer architectures

Sales code	Board	Description	Technical documentation
STEVAL-ISV008V1		300 W DC-DC converter with MPPT (40 Vdc output voltage solution, MPPT at cell string level)	
STEVAL-ISV009V1		300 W DC-DC converter with MPPT (40 Vdc output voltage solution, MPPT at panel level)	AN3392
STEVAL-ISV013V1		300 W high-voltage power optimizer for solar panels (400 V_{OUT} solution)	UM1471
STEVAL-ISV013V2		PLM communication daughter board for STEVAL-ISV013V1	
STEVAL-ISV013V3		ZigBee wireless communication daughter board for STEVAL-ISV013V1	
STEVAL-ISV018V1		300 W DC-DC converter with MPPT (120 Vdc output voltage solution, MPPT at cell string level)	

Microinverter based architectures

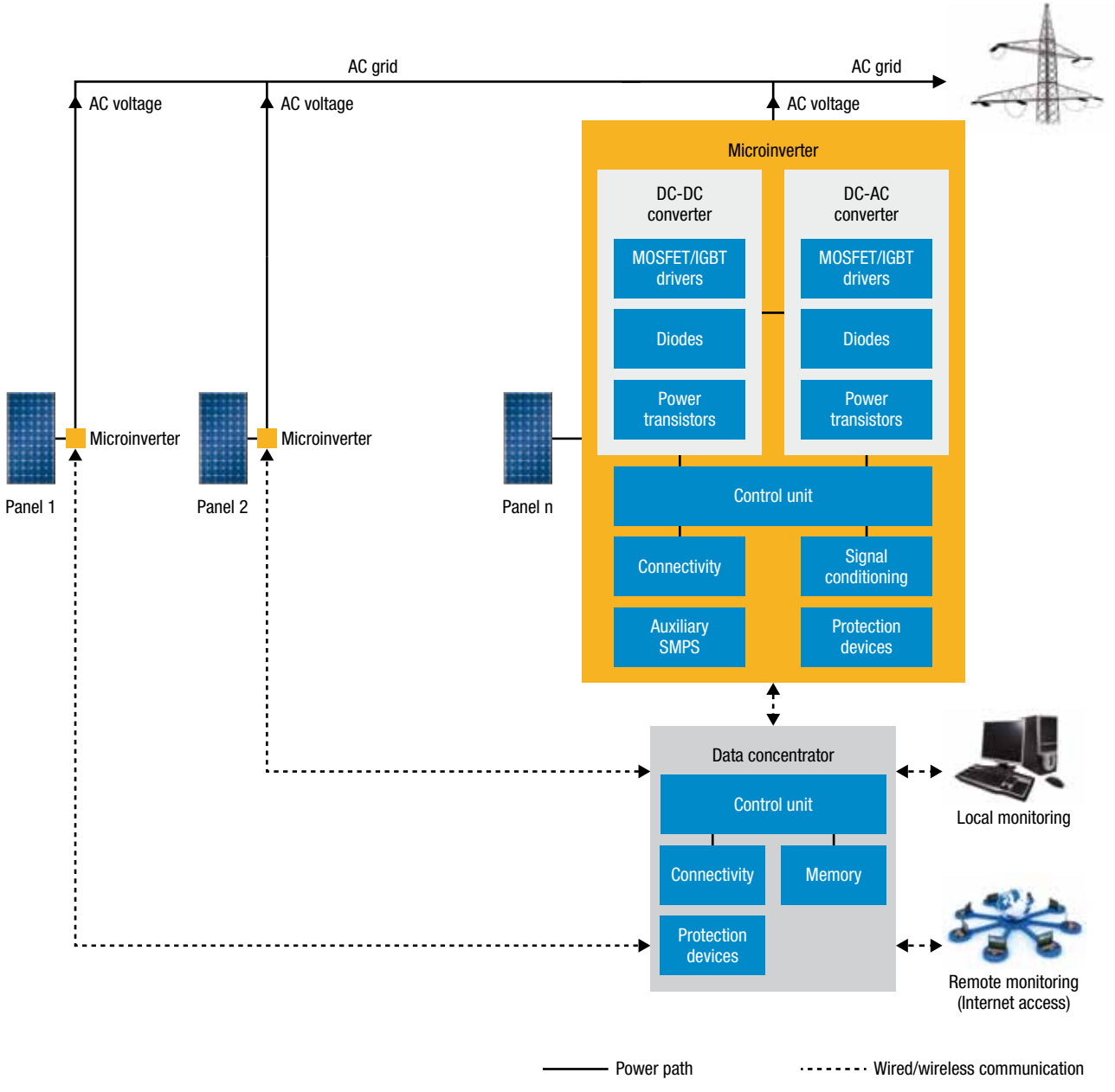
Architectures based on microinverters represent fully distributed photovoltaic grid-connected systems (Figure 5) in which all the electronics is moved close to each panel. This kind of architecture includes two main functional blocks:

- **The microinverter** provides the MPPT, the complete power conversion, the connectivity and AC grid connection. Single- or two-stage power conversion architectures can be used to convert DC voltage and current from the solar panel into AC voltage and current suitable for the grid. Panel-level connectivity allows remote monitoring of system performances.
- **The data concentrator** is the system that collects the data (voltage, current, etc.) coming from all the microinverters and sends it to a local or remote monitoring and control access point.

The microinverter approach thus includes all the electronics needed in the path from the sun to the grid at panel level, providing the following benefits:

- More energy production: the distributed MPPT at panel level guarantees the maximization of system energy production
- Smart communication and monitoring capabilities for each panel
- More flexibility: installations can be expanded over time without replacing a large centralized inverter
- The highest reliability: microinverter failure does not affect the overall system operation

Figure 5 Microinverter based architecture (simplified block diagram)



ST's product offering for microinverter architectures is shown below. The key products for each functional block described above are described in the table below.

Product offering for microinverter architectures

Functional block	Product family	Key products	Description
Microinverters	**Diodes**	STTH*BC	600/650 V high-voltage rectifiers for BC² topology
		STPSC*06	600 V silicon-carbide diodes
		STTH*R06 STTH*08 STTH*10 STTH*12	600 V to 1200 V high-voltage ultrafast rectifiers
		STPS*25 STPS*40 STPS*60	25/40/60 V power Schottky rectifiers
	Control units	STM32F103 STM32F107 STM32 F2 STM32 F4	32-bit ARM Cortex MCUs: - STM32 F1 Mainstream family - STM32 F2 High-performance family - STM32 F4 Hi-Performance & DSP
	MOSFET/IGBT drivers	TD350,TD351, TD352	Advanced gate drivers for IGBTs and power MOSFETs
		PM883*	High-frequency dual low-side drivers for high-capacitive MOSFETs and IGBTs
		L638*, L639*	Gate drivers with half-bridge driver structure for IGBTs and power MOSFETs
	Power transistors	STB*N80K5 STB*N90K5	800/900 V N-channel power MOSFETs in Zener protected SuperMESH™ 5 technology, D²PAK package
		STL23N85K5	850 V N-channel power MOSFET in Zener protected SuperMESH™ 5 technology, PowerFLAT™ 8x8 HV package
		STB*N65M5 STL*N65M5	650 V N-channel power MOSFTETs, MDmesh™ V technology - D²PAK package - PowerFLAT™ 8x8 HV /5x5 /5x6 HV packages
		STL23NM60ND STB*NM60ND	600 V N-channel power MOSFETs, FDmesh™ II technology - PowerFLAT™ 8x8 HV package - D²PAK package
		STB80N20M5	200 V N-channel power MOSFET, MDmesh™ V technology in D²PAK package
		STL70N10F3 STH130N10F3-2 STH180N10F3-2	100 V N-channel power MOSFETs, STripFET™ III technology - PowerFLAT™ 5x6 package - TO220FP and H²PAK-2 packages - H²PAK-2 package
		STH310N10F7-2	100 V N-channel power MOSFET, STripFET™ VII DeepGATE™ technology
		STL80N75F6 STL75N8LF6	75/80 V N-channel power MOSFETs, STripFET™ VI DeepGATE technology, PowerFLAT™ 5X6 package
	Auxiliary power supplies	Viper*7	High-performance off-line high-voltage converters
		STTH*06	600 V ultrafast high voltage rectifiers, Turbo2 technology
		STPS*60	60 V power Schottky rectifiers
		STD20NF20	200 V N-channel power MOSFET, STripFET™ technology
		P6KE, 1.5KE	600/1500 W Transil™ transient voltage suppressors
	Protection devices	SMBJ, BZW50	600 W/5 kW Transil™ transient voltage suppressors
		STIEC45	500 A power line surge current protection
	Signal conditioning	TS27	Micropower, high-voltage CMOS operational amplifier
		TS91*	Low-power operational amplifiers with CMOS inputs
	Connectivity	STM32W108	32-bit RF (ZigBee®) MCUs
		SPZB32W1x2.1	ZigBee® modules (ready-to-use) based on ST's STM32W108CB
		ST75*0	Power line transceivers (STarGRID™ family)
		ST3232	3 V powered EIA/TIA-232 and V.28/V.24 communication interface, low power
		ST485	5 V low-power, high-speed transceivers for RS-485 and RS-422 communications with ESD protection
		ST3485	3.3 low-power transceiver for RS-485 and RS-422 communications with ESD protection
		ST802RT	10/100 real-time Ethernet 3.3 V transceiver
		SMP	Trisil™ thyristor surge suppressor to protect high data rate communication equipment
		SM6T, SM15T	600/1500 W Transil™ transient voltage suppressors

Product offering for microinverter architectures (cont'd)

Functional block	Product family	Key products	Description
Data concentrators	**Control units**	STM32F103 STM32F107 STM32 F2 STM32 F4	32-bit ARM Cortex MCUs: - STM32 F1 Mainstream family - STM32 F2 High-performance family - STM32 F4 Hi-Performance & DSP
	Memories	M24C, M241, M242, M245, M24M, M93, M95	EEPROM serial memories
		M24LR	RF-I²C Dual Interface EEPROM memories
	Connectivity	STM32W108	32-bit RF (ZigBee®) MCUs
		SPZB32W1x2.1	ZigBee® modules (ready-to-use) based on ST's STM32W108CB
		SPBT2532	Bluetooth® module
		ST75*0	Power line transceivers (STarGRID™ family)
		ST3232	3 V powered EIA/TIA-232 and V.28/V.24 communication interface, low power, high data-rate capabilities
		ST485	5 V low-power, high-speed transceiver for RS-485 and RS-422 communications with ESD protection
		ST3485	3.3 V low-power transceiver for RS-485 and RS-422 communications with ESD protection
		ST802RT	10/100 real-time Ethernet 3.3 V transceiver
		SMP	Trisil™ thyristor surge suppressor to protect high data rate communication equipment
		SM6T, SM15T	600/1500 W Transil™ transient voltage suppressors
	Protection devices	SMBJ, BZW50	600 W/5 kW Transil™ transient voltage suppressors
		STIEC45	500 A power line surge current protection

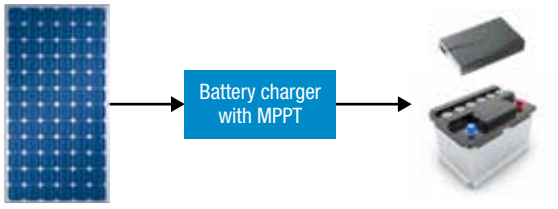
ST's evaluation board designed for the microinverter based architecture is shown below.

Evaluation board for microinverter architecture

Sales code	Board	Description	Technical documentation
STEVAL-ISV003V1		250 W microinverter	AN4070, UM1538

Solar battery applications

ST's solar battery chargers address both low- and high-power applications. ST offers a dedicated portfolio for both portable applications (such as mobile phones) and inland applications (such as solar LED street lighting). The products embed the MPPT algorithm, ensure the battery charging profile and provide full protection. Innovative system solutions are available to help engineers design these applications.



Product offering for solar battery applications

Product family	Key products	Description
Photovoltaic ICs	SPV1040	High-efficiency solar battery charger with embedded MPPT
	SPV1020	Interleaved DC-DC boost converter with built-in MPPT algorithm
Battery management ICs	L6924	Single cell Li-ion battery charger

Evaluation boards for solar battery applications

Sales code	Board	Description	Technical documentation
STEVAL-ISV005V2		240 W solar lead acid battery charger with MPPT: from PV panel to battery	AN3971
STEVAL-ISV006V2		5 W solar battery charger with MPPT	AN3319
STEVAL-ISV012V1		5 W solar charger with MPPT for single-cell Li-ion battery	AN4050
STEVAL-ISV014V1		5W solar charger with MPPT for single-cell Li-ion and Li-polymer batteries	

Featured products

STPS*45 Schottky diode series

ST's power Schottky diodes for solar applications feature a very low reverse leakage current (I_R) and an ultra-low forward voltage drop (V_F) for reduced forward power losses to improve efficiency of cells. They are housed in packages, in line with equipment constraints and customer needs. They also feature:

- A large safe operating area with a 175 °C rated junction temperature for higher reliability and efficiency
- A high forward surge current rating (I_{FSM}) to protect against current surges and lightning strikes
- A low profile height of 1.0 mm to fit the solar panel itself; this is achieved using our new power QFN 5x6 package

The package is RoHS compliant, uses green molding compound (bromine and antimony free), is lead-free, with 100% pure tin plating, withstands 260 °C IR reflow soldering and meets moisture sensitivity level 1 (MSL).
ST's product offering is ideal for solar applications, with the right V_{RRM}, the right average forward current, and the right power packages.

Key features

- Low reverse current
- Low forward voltage
- Low-profile packages
- Halogen free packages

Main benefits

- Increased panel efficiency
- Increased power density
- Environmental care

SPV100* cool bypass switch

In all photovoltaic applications when one solar cell of the panel is shaded while the others are illuminated, a hot spot could appear and lead to the shaded cell destruction. A cool bypass switch is the new efficient solution to eliminate hot spots and maintain current delivery.

The SPV1001 and SPV1002 are systems in package. They consist of a power MOS transistor suitably controlled in order to charge an embedded capacitor during the off time and drive its gate during the on time, with the charge accumulated in the capacitor. On and off times are appropriately set to reduce the average voltage drop across drain and source terminals and power dissipation.

This provides an extremely low reverse leakage current and a very low forward voltage drop.

This results in superior thermal performances that allow the cool bypass diode to work with very high current in a harsh enclosed environment such as a solar panel's junction box.

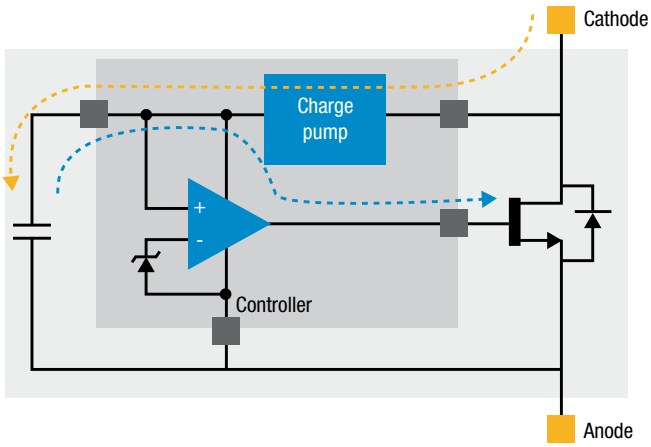
These devices are available in several packages such as TO220, D^2PAK and PQFN 5x6 to meet both the junction box and solar panel needs.

Key features

- System in package
- Embedded power MOSFET
- Very low forward-voltage drop
- Very low reverse leakage current

Main benefits

- Cooler than standard bypass diodes
- Low power dissipation
- Longer lifetime
- Higher reliability



SPV1020 monolithic interleaved DC-DC boost converter with MPPT

The SPV1020 is a monolithic DC-DC boost converter designed to maximize the power generated by photovoltaic panels. Power conversion is optimized with an embedded logic that performs the MPPT algorithm. Since the maximum power point is locally computed, the efficiency at system level is higher than for conventional topologies.

The SPV1020 embeds the power MOSFETs for active switches and synchronous rectification, minimizing the number of external components. Furthermore, the 4-phase interleaved topology of the DC-DC converter avoids the use of electrolytic capacitors. The device is available in PowerSSO-36 package.

Key features

- PWM mode DC-DC boost converter
- Operating voltage range: 0 to 45 V
- Maximum input current: 6.5 to 45 A
- Overvoltage, overcurrent and over-temperature protection
- Built in soft-start
- Up to 98% efficiency
- Automatic transition to burst mode for improved efficiency at low solar radiation
- SPI interface

Main benefits

- Panel level MPPT optimizes each panel separately, minimizing impact of temperature variation and cell mismatch due to manufacturing spread
- Remote control and monitoring for easy module and string-level fault detection with power line or wireless technology
- Bypass and cutoff diodes can be removed; the main inverter can be simplified
- Cost: by using very fine lithography, power switches, analog and logic are integrated on one chip giving a very cost-effective solution
- Reliability: fewer devices on the board means lower failure rate over time
- Increased power density

STM32 F4 high-performance Cortex™-M4 MCU series

The ARM® Cortex-M4-based STM32 F4 series is an extension of the industry-leading STM32 portfolio towards even higher performance. Like the STM32 F2 series, these MCUs leverage ST's 90 nm NVM technology and ST's ART Accelerator™ to reach the industry's highest benchmark scores for Cortex-M-based microcontrollers with 210 DMIPS at 168 MHz operating frequency.

The DSP instructions and the floating point unit (FPU) enlarge the range of addressable applications. The STM32 F4 series is the result of a perfect symbiosis of the real-time control capabilities of an MCU and the signal processing performance of a DSP, and thus complements the STM32 portfolio with a new class of devices, digital signal controllers (DSC).

The STM32 F4 series remains pin-to-pin and software compatible with the STM32 F2 series (based on Cortex-M3) and features more SRAM, peripheral improvements such as full duplex I²S, improved RTC and faster ADCs.

The devices are available in WLCSP (< 4.5 x 4.5 mm), LQFP64, LQFP100, LQFP144, LQFP176 and UFBGA176 packages.

Key features

- Cortex-M4 with F_{CPU} 168 MHz/210 DMIPS
- <1 µA V_{BAT} RTC, ultralow dynamic consumption, 1.7 to 3.6 V V_{DD}
- 2 full duplex I²S
- RTC with sub-second accuracy
- 1-Mbyte Flash, 192-Kbyte SRAM
- 3x 12-bit ADC, 0.41 µs/2.4 MSPS

MDmesh V power MOSFETs

The best $R_{DS(on)}$* area on the market at 550 V and 650 V

The improvement in $R_{DS(on)}$ achieved with MDmesh V significantly reduces losses in line-voltage PFC circuits and power supplies. This in turn enables new generations of electronic products offering greater energy savings, superior power density, and more compact applications. This new technology helps product designers tackle emerging challenges such as the high-efficiency targets of new eco-design directives, and also benefits the renewable energy sector by saving vital watts normally lost in power-control modules. MDmesh V is a silicon-based technology, which combines an innovative proprietary vertical technology process with the Company's well-known PowerMESH™ horizontal layout.

This technology achieves up to 40% better $R_{DS(on)}$ versus the previous MDmesh II technology and establishes a new milestone in the power switch arena becoming the world's best $R_{DS(on)}$* area (with 550 V and 650 V at 25 °C breakdown voltage) in TO-220, TO-220FP, I^2PAK, D^2PAK, DPAK, IPAK, TO-247 and Max247 packages.

The fast switching and extremely low $R_{DS(on)}$ yields elevated energy savings, fast switching, high electrical efficiency, more compact designs and superior high power density. As a result, the device is more reliable and long lasting for SMPS, solar-converter, lighting and display applications.

New PowerFLAT™ 8x8 HV packages are available for needs of photovoltaic applications.

Key features

- Worldwide best $R_{DS(on)}$* area in many packages
- Fast switching
- Higher V_{DSS} rating
- High dV/dt capability
- Easy to drive
- PowerFLAT 8x8 package

600 V ultra-fast HF IGBTs: STGW*HF60WD* series

The new family of ultra-fast (W series) 600 V HF IGBTs improves the power efficiency in high frequency equipment by minimizing turn-off energy losses mainly at frequencies up to 100 kHz.

The new series, which includes 35 A (STGW*35HF60WD*) and 45 A (STGW*45HF60WD*) devices, simplifies parallel connection for higher power levels as a result of the $V_{CE(sat)}$ rating. It also achieves up to 10% better performance in conduction and switching losses, and lower spread of dynamic parameters, even at high temperature compared to the previous generation products.

Both the innovative double-drift process and the advanced planar strip layout give the HF W series IGBTs extremely fast turn-off times with a minimal tail current, as well as stable behavior over temperature allowing the application to provide high efficiencies.

A co-packaged antiparallel diode, provided with a double option (ultra-fast or low drop soft recovery), optimizes the overall performance in both hard switching (welding, UPS, photovoltaic, SMPS) and soft switching (induction heating, resonant converters) applications.

The devices are offered in both industry-standard TO-247 and long-lead TO-247 (higher power dissipation) packages.

Key features

- High operating frequency (over 100 kHz)
- Improved switch-off energy spread versus increasing temperature
- Lower on-voltage drop
- Anti-parallel diode tailored to the application

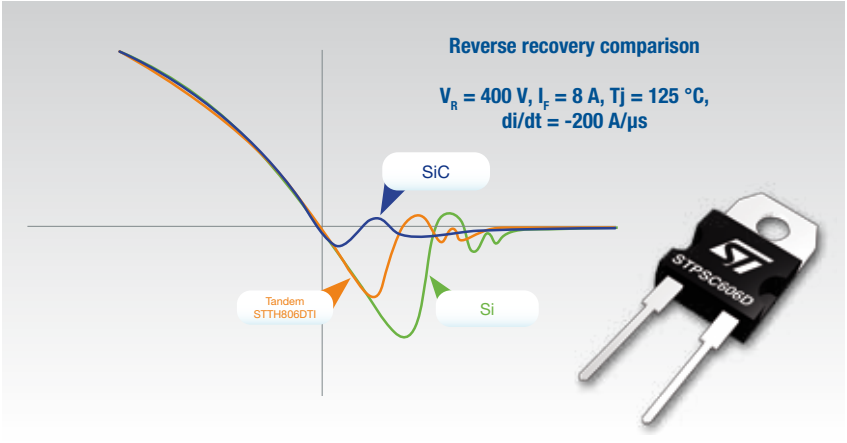
Main benefits

- E_{OFF} max value guaranteed at spec both for 25 °C and 150 °C
- Lower static power losses
- Easy parallel connection
- Lower E_{ON} losses

STPSC*06 600 V instant switching SiC diodes

These silicon-carbide (SiC) structured Schottky diodes exhibit a dynamic characteristic 4 times better and a forward voltage drop 15% less than the fastest bipolar silicon diodes available on the market. This performance breakthrough enables all targeted applications to reach an unequalled level of efficiency and power density, as well as switching frequencies. The product range includes 600 V, 4 A, 6 A, 8 A,10 A and 12 A devices, housed in TO-220AC packages. A DPAK version is available on the 4 A SiC diode, and D²PAK on the 6, 8 and 10 A diodes.

Trials have shown efficiency improvements of 0.5%, and up to 1% at high load and high frequency when using a SiC diode in the application. The second direct improvement is the power density through the reduced mechanical size of the magnetic elements as a result of the potential increase in the switching frequencies when using SiC diodes. Finally, the noise-free characteristic of SiC diodes requires smaller EMI filters, which further increases the power density.



Key features

- Silicon carbide Schottky diode
- No or negligible reverse recovery characteristics
- Switching behavior independent of the temperature
- Facilitates parallel and series operation thanks to positive thermal coefficient on V_F

Main benefits

- Efficiency increased by up to 1% versus conventional ultrafast silicon diodes
- Reduced reverse recovery characteristics for less EMI in the application, and associated filter size and cost reduction
- Power density increased through higher switching frequency operations or dI/dt

ST75*0 STarGRID™ power-line communication SoC platform

STarGRID is a unique flexible, scalable and future-proof power-line communication system-on-chip platform that effectively addresses demanding smart-metering and smart-grid application requirements and related standards. The STarGRID platform includes the ST7570, ST7580, and ST7590 products. By optimizing power consumption and system cost, the STarGRID platform is also ideal for many other green applications, including smart-energy control in photovoltaic modules, electric vehicle networking, home area networking and street lighting management.

The STarGRID platform combines a high-performance DSP core with a programmable protocol engine, along with the full analog front end (AFE) and power-line driver in a single chip, for a complete, flexible and cost-effective narrowband power-line communication solution.

Key features

- Fully-integrated narrowband power-line networking system-on-chip
- High-performance DSP with embedded programmable turnkey firmware for multiple-modulation management
- Convolutional correction coding
- Programmable bit rates up to 128 Kbit/s
- Channel quality estimation
- Host UART/SPI controller
- I^2C/SPI external data memory interface
- High-speed memory controller for optional code execution from external memory
- Watchdog timer

- On-chip 128-bit AES encryption HW block
- Fully integrated analog front end
- High-sensitivity receiver
- High-linearity transmitter
- Embedded single-ended power amplifier delivering up to 1 Arms, 14 Vpp output
- Embedded temperature sensor and current control features
- Suitable for applications compliant with CENELEC EN50065 and FCC specifications
- -40 °C to +85 °C temperature range
- QFN48 7x7 exposed pad

SPV1040 solar battery charger with embedded MPPT

The SPV1040 is a high-efficiency, low-power, low-voltage DC-DC step-up converter that maximizes the energy transferred from the solar panel to the load using an embedded MPPT algorithm. It is based on a perturb-and-observe method which applies a duty cycle variation to a PWM signal according to the input power trend.

In addition, the device guarantees the safety of the application by implementing either an overcurrent or over-temperature protection and regulating the battery voltage at all times.

The 0.3 V start-up input voltage is well suited to any portable application where only a few photovoltaic power cells are used.

Key features

- 0.3 V up to 5.5 V input operating voltage
- 120 mΩ internal active switch
- 140 mΩ internal synchronous rectifier
- 2 up to 5.2 V output voltage regulation
- 1.8 A maximum input current
- 155 ºC over-temperature shutdown

Key benefits

- Energy harvesting in very low-power applications
- Up to 95% efficiency
- Battery charge current monitoring
- Output voltage regulation
- Thermal protection

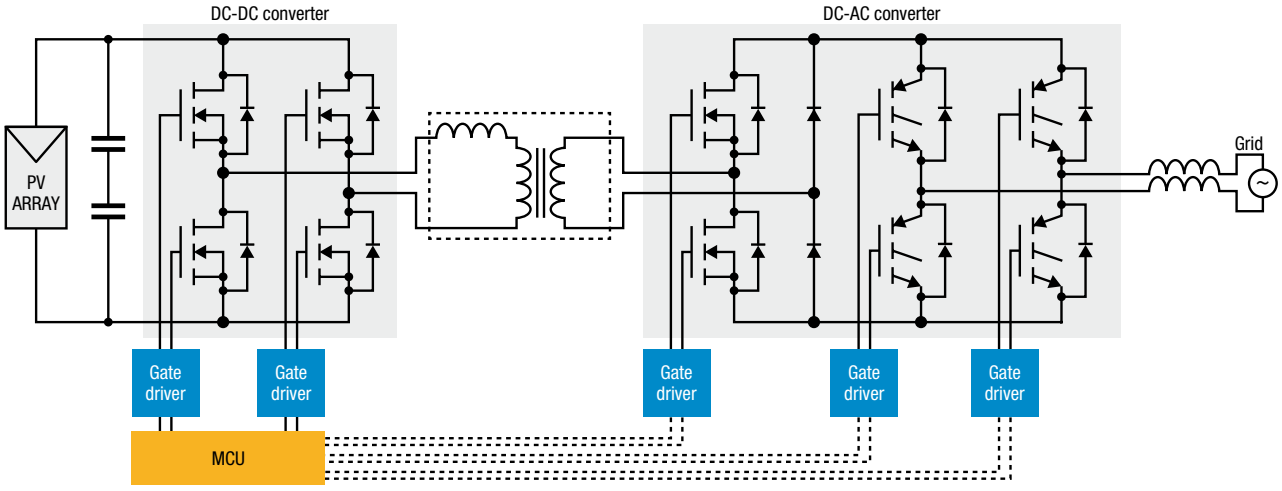
Featured solutions

3 kW grid-connected solar inverter

This demonstration board is a converter specifically developed for PV applications to significantly reduce production costs and increase efficiency. The inverter manages and transforms all the energy produced by the panel array. It consists of a high-frequency isolated input power section performing DC-DC conversion and an inverter section (DC-AC conversion) capable of delivering a sinusoidal current of 50 Hz to the grid.

The system operates with input voltages in the range of 200 to 400 V and is tied to the grid at 230 Vrms, 50 Hz, through an LCL filter. Other specific characteristics of the converter are the high level of integration, decoupled active and reactive power control and flexibility towards the source. The solution features a fully digital control algorithm, including power management for grid-connected operation and an MPPT algorithm, using the latest generation 32-bit STM32 microcontrollers.

System architecture



Key features

- High conversion efficiency: 97%
- Phase-shift DC-DC converter with MPPT plus full-bridge DC-AC converter
- Optimized MPPT algorithm for maximum energy yield from PV array
- Galvanic isolation between PV array and grid
- Grid-connected algorithm with decoupled control of active and reactive power
- Anti-islanding function

Key products

- STM32F103ZE (32-bit microcontroller)
- STW55NM60ND (power MOSFET)
- STGW35HF60WD (IGBT)
- L6386D, TD350 (MOSFET/IGBT drivers)
- STTH60L06, STTH30R06, STTH16L06, STPS3150, STPS5L40 (diodes)
- ST3232EB (RS-232 interface)
- VIPer17, VIPer27 (aux. SMPS)

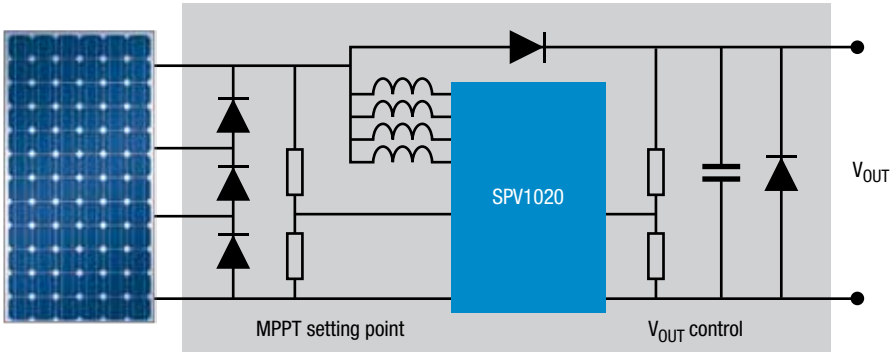
Order code:
STEVAL-ISV002V2

Technical documentation:
AN3095, UM1016

250 W low-voltage power optimizer

This low-voltage power optimizer is designed for photovoltaic systems in low-voltage distributed architecture. This demonstration board is based on the SPV1020, which is a monolithic DC-DC boost converter designed to maximize the power generated by photovoltaic panels whatever the temperature and amount of solar radiation. Power conversion is optimized with embedded logic which performs the MPPT perturb-and-observe algorithm on the PV cells connected to the converter. The board is able to manage a 250 W panel and provides a low DC output voltage (40 V maximum). By using the SPV1020, the board is reduced in size and electrolytic capacitors are not required, so increasing lifetime. The bypass function is ensured using ST's new SPV1001 cool bypass switches.

Safety of the power optimizer is implemented by stopping the drivers in case of output overvoltage or over-temperature. An SPI interface for remote telemetry and control is included.



Key features

- 250 W DC-DC boost converter with MPPT
- 40 V output voltage range
- Built-in MPPT and soft start
- Output overvoltage and over-temperature control
- Efficiency >98%
- SPI interface for remote

Key products

- SPV1020 (solar energy booster)
- SPV1001N30, SPV1001N40 (cool bypass switches)
- STPS160 (power Schottky diode)

Order code:
STEVAL-ISV009V1

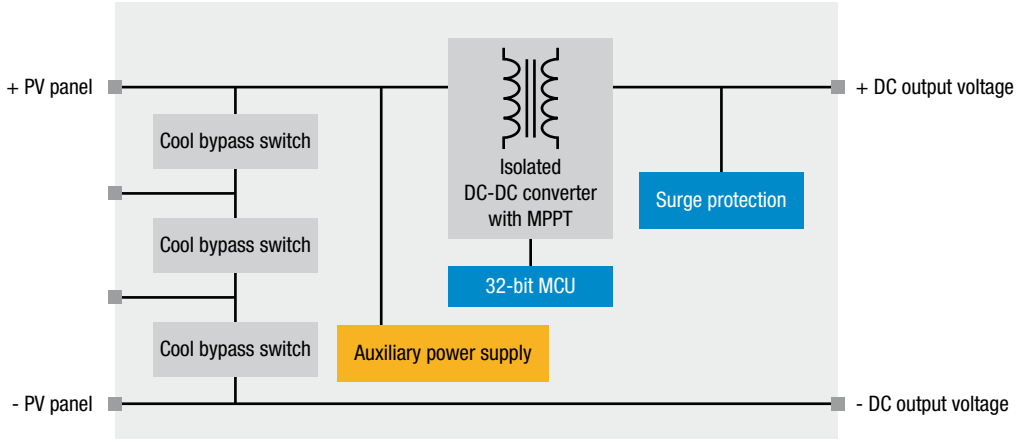
Technical documentation:
AN3392

250 W high-voltage power optimizer platform

The high-voltage power optimizer platform is designed for photovoltaic systems in distributed architecture. This platform offers an easy-to-use, fully-protected solution to implement high-efficiency DC-DC conversion combined with distributed MPPT and real-time panel diagnostics. The platform consists of a power optimizer board (STEVAL-ISV013V1) coupled with a communication board (STEVALISV013V2 or STEVAL-ISV013V3).

The power board is a DC-DC isolated boost converter that can manage a 250 W panel and provides a high DC output voltage (from 350 to 430 V). The communication, depending on the board chosen, is obtained via PLM or via RF-ZigBee. The high-voltage power optimizer approach is the basis for the latest configurations of PV panels (all panels are connected in parallel to the high-voltage DC bus) that focus on increasing the panel energy produced and simplifying the photovoltaic field design and realization. Furthermore, maintenance costs are reduced through the possibility of monitoring an individual panel's status and communicating the data to a remote control unit. The power board features an MPPT algorithm (perturb and observe) searching for the best working point of the panel, maximizing the energy produced under all environmental conditions. The specific functions of this platform, such as safe operation (electrical maintenance and fire extinguishing), antitheft protection and remote panel shutdown, increase safety and security of the PV system. Safe operation is guaranteed even without a transceiver.

Power board block diagram



Key features

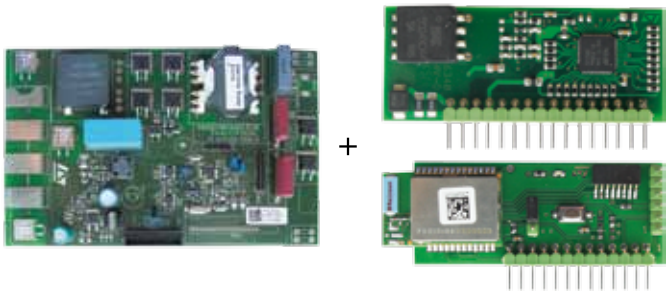
- Power capability: 250 W
- High output DC voltage: from 350 to 430 V
- High conversion efficiency: >97%
- Distributed MPPT at module level (99% efficiency)
- Embedded smart communication
- Cool bypass technology for hotspot protection
- Antitheft protection, remote panel shutdown and maintenance safe operations

Key products

- STM32F103CBT7 (32-bit microcontroller)
- STH180N10F3-2, STD20NF20 (power MOSFETs)
- STTH12R06G, STPS2H100, STPS1R60 (diodes)
- SPV1001 (cool bypass switch)
- L6385E (MOSFET/IGBT drivers)
- ST7580 (power line modem)
- STM32W108CB (32-bit RF(ZigBee) MCU)
- SMBJ70CA, SMAJ70 (protection)

Order code:
STEVAL-ISV013V1
(power board)
STEVAL-ISV013V2
(PLM communication board)
STEVAL-ISV013V3
(RF-ZigBee communication board)

Technical documentation:
UM1471



250 W microinverter plug-in solution for PV panels

This demonstration board is a 250 W microinverter system suitable for operation with standard photovoltaic (PV) modules and able to generate grid-compatible power. The module-level maximum power point tracking (MPPT) on the STEVAL-ISV003V1optimizes solar energy harvesting by minimizing losses due to dust, debris, variable shading and module mismatch.

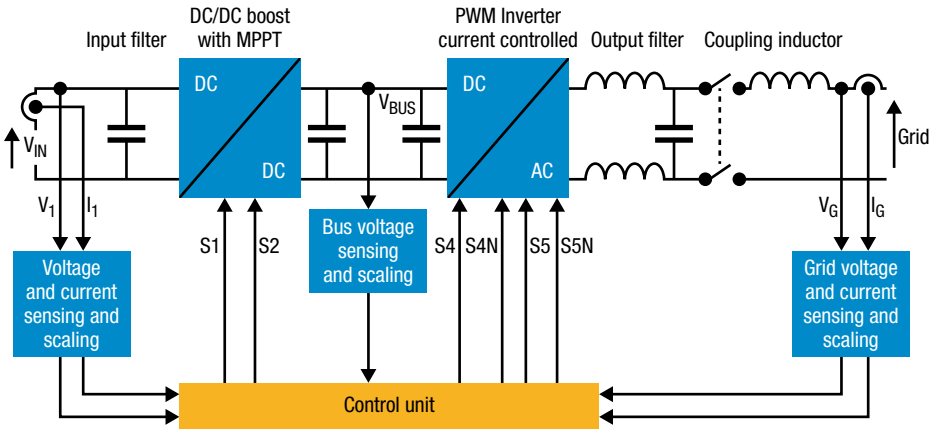
PV modules equipped with a microinverter can be plugged directly into the AC grid, overcoming the limitations of traditional PV systems and ensuring energy generation even with a single-panel or central-inverter failure. The microinverter approach eliminates the need for expensive inverter replacement, so lowering operating costs and making PV installations more flexible.

The STEVAL-ISV003V1 supports an input voltage from 18 to 56 V and is based on a two-stage architecture which ensure 94% conversion efficiency (93.5% CEC efficiency) and features a decoupled control of active and reactive power. The two stages are as follows:

- A DC-DC isolated interleaved boost converter
- A DC-AC full bridge PWM inverter with hybrid modulation (mixed frequency)

The first stage steps up the input voltage to the 390 to 450 V_{DC} bus with high efficiency and implements the MPPT algorithm. The DC-AC stage generates a 230 V_{AC}, 50 Hz or 240 V_{AC}, 60 Hz sine wave. Connection to a 120 V_{AC}, 50/60 Hz grid is achieved with only a few hardware modifications.

Block diagram



Key benefits

- Conversion efficiency: > 94%
- MPPT efficiency: 99%
- Grid-connected algorithm with decoupled control of active and reactive power
- Overcurrent and anti-islanding protection

Key products

- STM32F103ZE (32-bit microcontroller)
- STB18N65M5, STH180N10F3-2 (power MOSFETs)
- PM8834, L6390 (MOSFET drivers)
- STPSC606, STPS1545C, STTH12R06 (diodes)
- ST3232EB (RS-232 interface)

Order code:
STEVAL-ISV003V1

Technical documentation:
AN4070, UM1538

Order code: BRSOLAR0812

For more information on ST products and solutions, visit **www.st.com**