APPLICATION NOTE

POWER AND CONTROL SOLUTIONS FOR INVERTERS

Microgrids (UL)

Are you looking for power and control solutions for stable and seamless transitions in your microgrid?

ABB offers solutions to help improve performance, energy consumption, and design time for microgrid inverters.

What are microgrids?
Microgrids are localized and decentralized energy systems that can operate independently or in conjunction with the main utility grid. Their ability to generate, store, and distribute power locally allows them to maintain a stable and reliable power supply within a specific area, even during power outages.

What are inverters?
Inverters are electronic devices used to convert direct current (DC) power to alternating current (AC) power. They are critical components in AC and DC microgrids. To make a microgrid system, they are combined with the microgrid bus, photovoltaic (PV) panel, wind turbine, battery energy storage system (BESS), and AC or DC loads.

Why is power and control important for microgrid applications?
Power and control are essential for microgrid applications because energy balance and grid reliability require maintaining the electrical system stability despite the variability in renewable production and load requirements. Adequate power and control systems help to manage critical transitions between grid-connected and islanded modes of operations in a microgrid without service interruptions. Proper power and control systems are necessary for resource coordination and power quality assurance.

Main benefits

Continuous operation
Our advanced solutions provide superior short-circuit protection and advanced trip units help to enhance system reliability and power quality by identifying voltage instabilities.

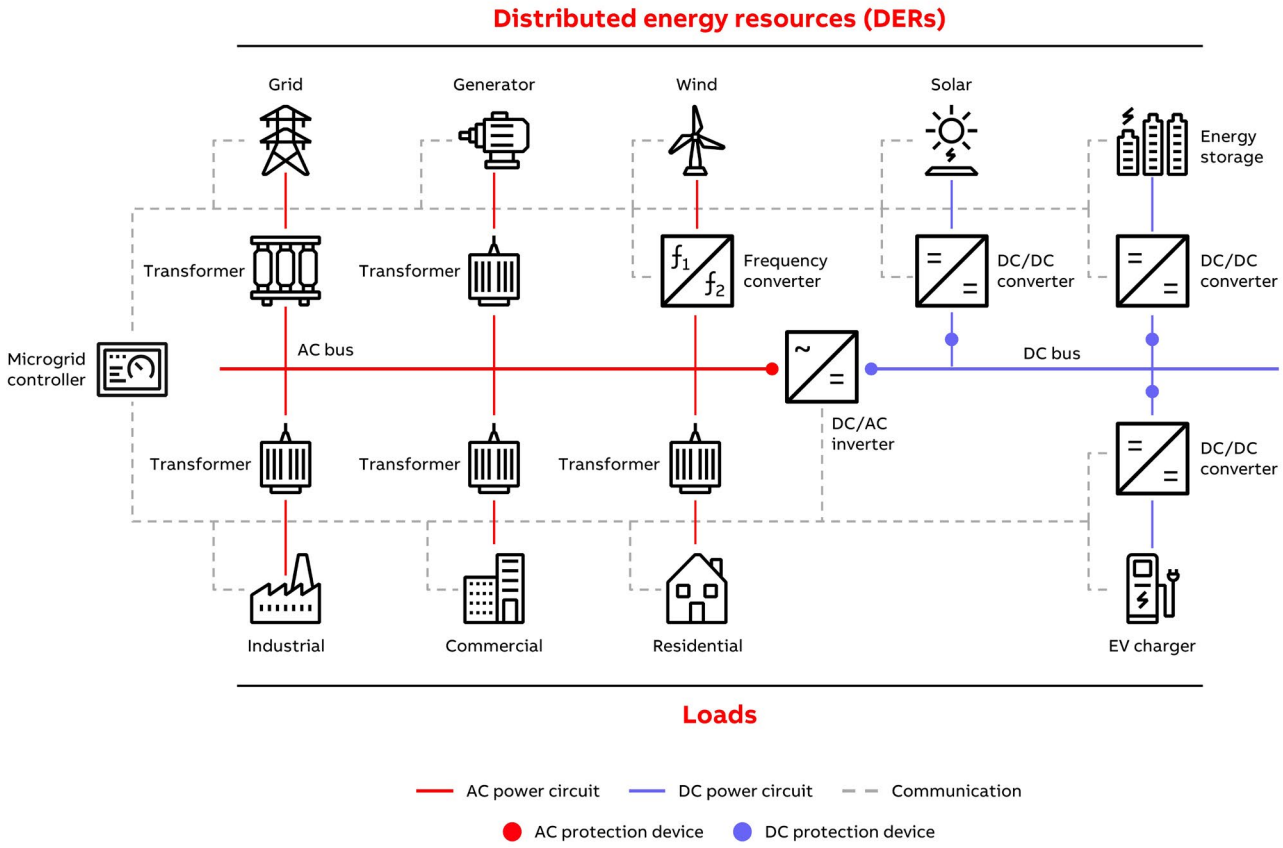
Energy-efficiency
Our innovative solutions optimize energy consumption, reducing operational costs and promoting sustainability in microgrid applications.

Smart metering & monitoring
Integrated metering and monitoring capabilities and interconnectivity with several communication protocols provide real-time insights into system performance, enabling proactive management and improved reliability.

Compact & easy to install
Compact designs and user-friendly installation features help reduce setup time and save valuable space in control panels, making integration into microgrid systems simple.

ENGINEERED TO OUTRUN

Microgrids overview



The main components of a microgrid

Microgrids include several key components that need to communicate effectively to operate as intended. First is the **utility grid**, a network that interconnects the generation, transmission, and distribution units in power systems. The grid has traditionally been our primary power source, but now there are more options available with grid-connected or off-grid microgrids.

Next are **distributed energy resources (DERs)**, which are sources of electric power often connected to the grid and/or local power system. Examples of DERS include solar panels, wind turbines, or hydrogen fuel cells.

A **battery energy storage system (BESS)** operates similarly to a DER by providing stored energy, but it can also be recharged for later use. Because of this bidirectional flow of power, they are considered integral components of a microgrid.

For all the DERs to provide energy to different systems, **power conversion equipment** is necessary. This equipment converts electrical energy between different voltage levels or between alternating current (AC) and direct current (DC).

This generated power is then fed to **loads**, which refer to the devices and processes that use electrical energy. Different types of loads include residential homes, commercial buildings, industrial facilities, and electric vehicle (EV) chargers.

All the components in a microgrid connect to an electrical connection pathway called the **AC/DC bus**, which distributes either AC or DC power to various components in the system.

Lastly, the system requires a **microgrid controller** for interoperability. It is a device that monitors and manages the DERs and loads connected to a microgrid to ensure it operates efficiently, reliably, and safely.

Why inverters are important

Inverters are critical components in a microgrid system since they act as a bridge between DC and AC systems. Inverters can be categorized in several ways based on their power circuit structure, control function, configuration topology, and connection type. The different types of inverters based on the different categories are:

Categories	Types
Power circuit structure	Single phase & three phase Series & parallel Voltage source (VSI) & Current source (CSI) Half bridge & full bridge
Control function/mode of operation	Grid-forming Grid-feeding/grid-following Grid-supporting/grid conditioning
Configuration topology	Central inverters String inverters Multi-string inverters Module/micro inverters
Connection	Stand-alone Grid-connected Bimodal

Inverter roles and benefits in a microgrid system are listed below:

Roles

- Essential for converting and managing electrical energy between various energy sources
- Enables the integration of diverse energy sources
- Necessary for power quality management by reducing frequency distortion, ensuring stable voltage, and managing fluctuations
- Helps to maintain the stability, efficiency, and reliability of microgrids

Benefits

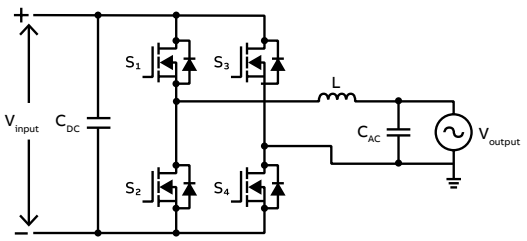
- Improves the efficiency of microgrid systems
- Better control of power quality has helped to harness solar, wind energy, and BESS on a larger scale
- Pivotal in enhancing the resilience and sustainability of power systems
- Enables dynamic energy management and real-time response to changing load conditions

Inverter types based on power circuit structure

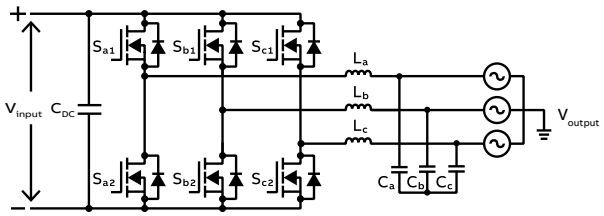
Inverters can be categorized based on their power circuit structure, which describes the specific configuration and arrangement of electronic components that convert DC to AC power. This structure determines how the inverter operates, the quality of the output waveform, its efficiency, and its suitability for various applications.

Different power circuit structures offer distinct advantages in complexity, cost, scalability, and performance, making this classification important when designing microgrid inverters. Some of the types of inverters based on a specific power circuit structure are:

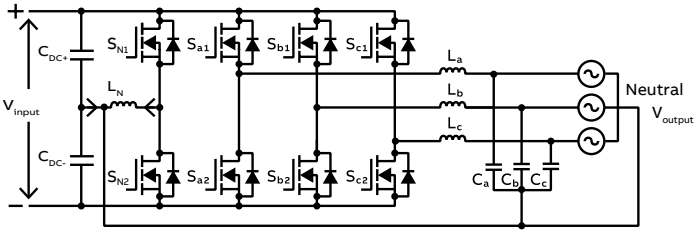
Single-phase inverters
Single-phase inverters convert DC voltage to a single-phase AC voltage with variable frequency. They are used for small loads and power supply. They are essential in solar PV systems because they allow generated power to be supplied to a network with fixed voltage and frequency.



Three-phase inverters
Three-phase inverters convert DC voltage into three-phase AC voltage, where each phase is 120 degrees out of phase with the other phases. They are critical for converting DC power to 3-phase AC power.



Three-phase four-wire inverters
Three-phase four-wire inverters are three-phase inverters with a neutral point and grounding/zero-sequence path, enabling balanced power distribution and integration with three-phase loads. These inverters can handle the neutral current due to unbalanced and/or nonlinear loads and suppress ground fault overvoltage.



Legend

V_{input} – Input Voltage	S – Switch
V_{output} – Output Voltage	C – Capacitor
L – Inductor	R – Load

Inverter types based on the microgrid control strategy

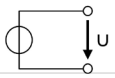
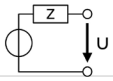
Inverters can also be categorized based on their control function or mode of operation, specifically how they synchronize and interact with the power grid or other sources in a microgrid system. This classification reflects the inverter's role in maintaining voltage and frequency stability, regulating power flow, and supporting grid reliability. Depending on their synchronization capability, inverters can follow an existing grid signal, form the grid by establishing a voltage and frequency reference, or support grid operations by adjusting output based on grid conditions.

Grid-forming

Grid-forming inverters are used in microgrid systems with energy storage devices.

- For **grid-connected operations**, they regulate AC voltage (reactive power) and frequency support (active power) injected to the AC bus to maintain the state of charge of the energy storage device.
- For **islanded operations**, they act as voltage sources with low output impedance in series by forming the sinusoidal voltage in the bus.

These inverters can be operated without being connected to the main grid.

	Grid-forming	Grid-feeding	Grid-supporting
Source type	Ideal voltage source	Ideal current source	Non-ideal voltage source
Control type	Const. frequency/ voltage	PQ control	Droop control
Output impedance	Z=0	Z=∞	Finite, non-zero
Output frequency	Fixed frequency	Grid synchronized	Frequency droop
Application	Island grid/ isolated	Grid-connected	Grid-connected or isolated
Equivalent circuit			

Grid-following or Grid-feeding

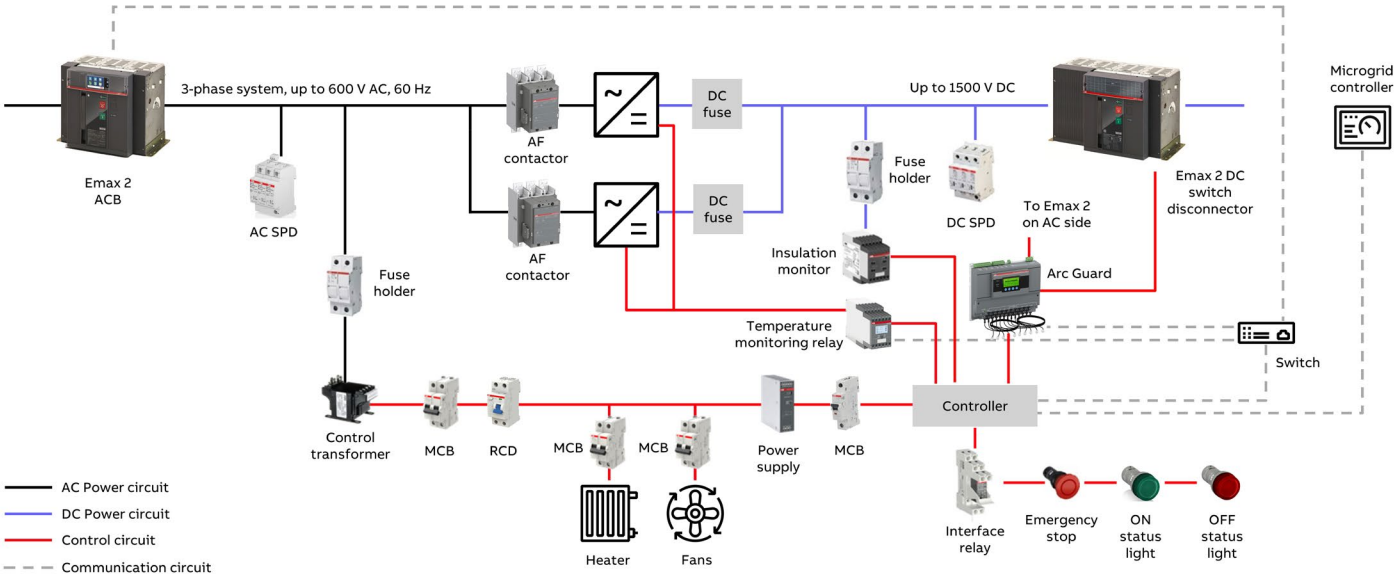
Grid-feeding inverters are used with non-dispatchable sources such as PV arrays and wind turbines, and their function is to inject power generated into a grid with a unitary power factor. They operate as current sources and generate constant active and reactive power to meet the demand. Their operation depends on at least one grid-forming converter.

These inverters cannot work without being connected to the main grid.

Grid-supporting

Grid-supporting inverters are used in inverter-dominated grids, where neither grid-forming nor grid-feeding behavior is dominant. This is because the inverters share active and reactive power and form the grid voltage and frequency. This is achieved by using droop control and a non-ideal voltage source.

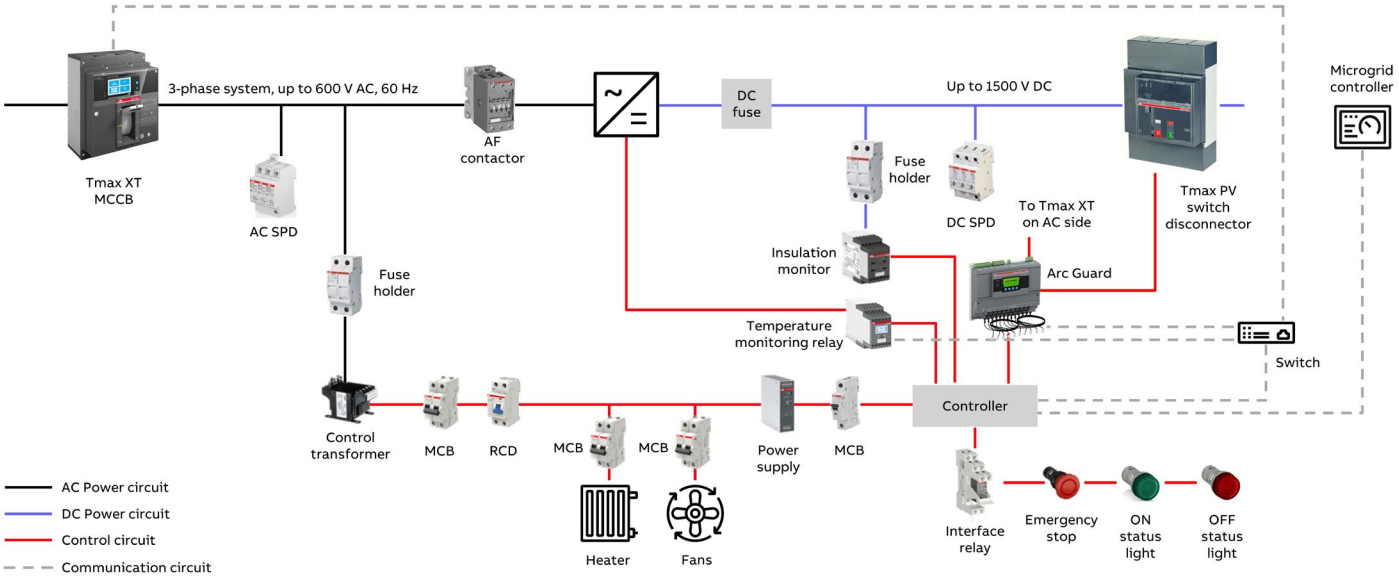
Power and control solutions for LV utility inverters



Note: This configuration is for a generic system and is not representative of existing manufacturers.

AC side	
Emax 2 ACB	For protection and isolation
SPD	For protection against overvoltages
AF contactor	For switching on each inverter branch
Arc Guard	For Arc Flash mitigation
DC side	
Emax 2 DC switch disconnector	For isolation and remote operation
SPD	For protection against overvoltages

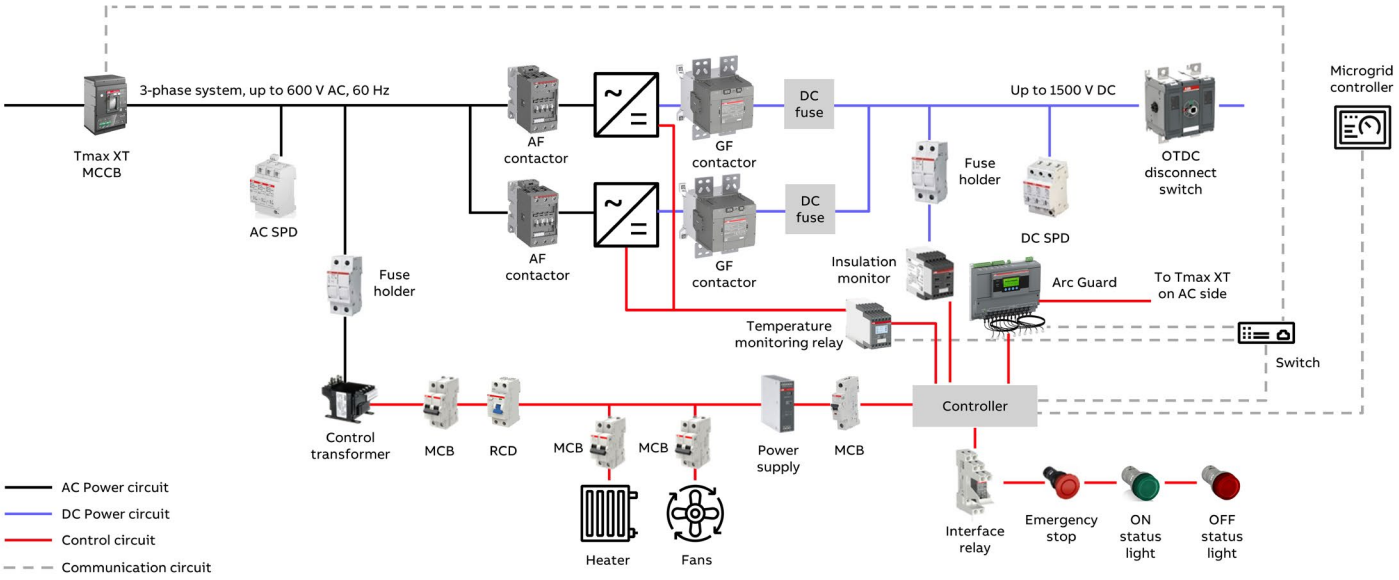
Power and control solutions for LV commercial & industrial inverters



Note: This configuration is for a generic system and is not representative of existing manufacturers.

AC side	
Tmax XT MCCB	For overload and short circuit protection
AF contactor	For switching on each inverter branch
SPD	For protection against overvoltages
Arc Guard	For Arc Flash mitigation
DC side	
Tmax PV switch disconnector	For isolation and remote operation
SPD	For protection against overvoltages

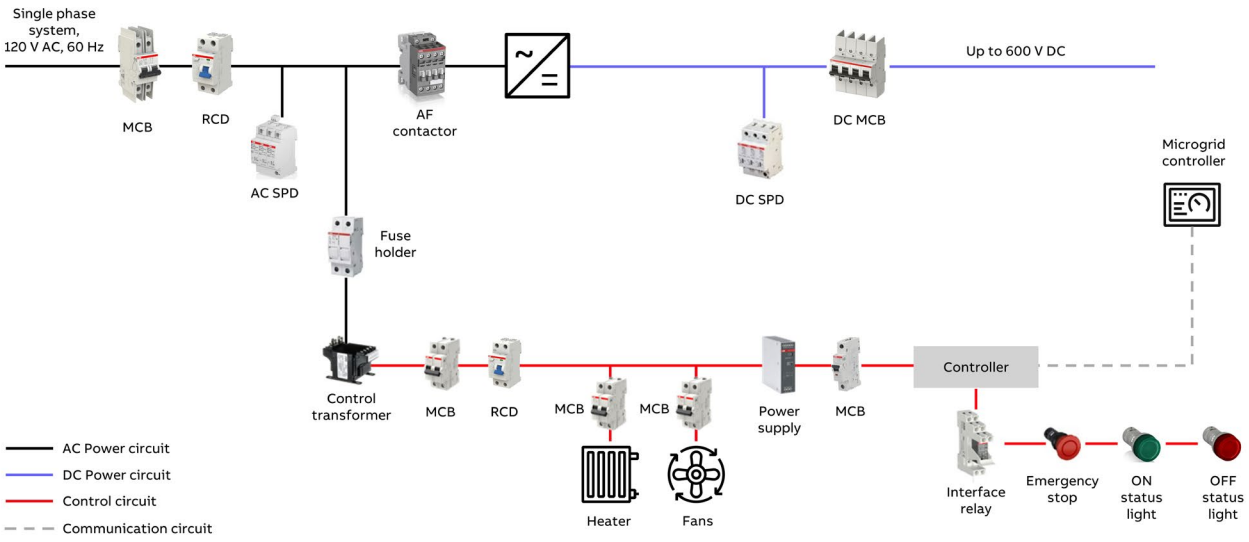
Power and control solutions for LV commercial & industrial inverters



Note: This configuration is for a generic system and is not representative of existing manufacturers.

AC side	
Tmax XT MCCB	For protection and isolation
AF contactor	For switching on each inverter branch
SPD	For protection against overvoltages
Arc Guard	For Arc Flash mitigation
DC side	
GF contactor	For switching combined with fuses on each inverter branch
OTDC disconnect switch	For isolation
SPD	For protection against overvoltages

Power and control solutions for LV residential inverters



Note: This configuration is for a generic system and is not representative of existing manufacturers.

AC side	
MCB	For overload and short circuit protection
RCD	For ground fault protection and fault detection
SPD	For protection against overvoltages
AF contactor	For remote isolation and control
DC side	
SPD	For protection against overvoltages
MCB	For overload and short circuit protection

Product offering

Tmax XT MCCBs

CATALOG LINK

WEB PAGE

Emax 2 ACBs

CATALOG LINK

WEB PAGE

Tmax PV MCCBs

CATALOG LINK

WEB PAGE

Emax 2/E ACBs

CATALOG LINK

WEB PAGE

Emax 2 MS/DC-E switch disconnectors

CATALOG LINK

WEB PAGE

Arc Guard Systems

CATALOG LINK

WEB PAGE

OTDC disconnect switches

CATALOG LINK

WEB PAGE

GF contactors

CATALOG LINK

WEB PAGE

Residual current devices

CATALOG LINK

WEB PAGE

AF contactors

CATALOG LINK

WEB PAGE

Surge protection devices

CATALOG LINK

WEB PAGE

Fuse holders

CATALOG LINK

WEB PAGE

Control transformers

CATALOG LINK

WEB PAGE

Miniature circuit breakers

CATALOG LINK

WEB PAGE

Measuring and monitoring relays

CATALOG LINK

WEB PAGE

Power supplies

CATALOG LINK

WEB PAGE

Product offering

Interface relays and optocouplers

CATALOG LINK

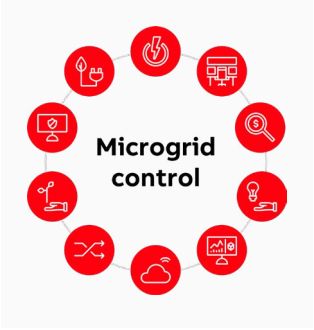
WEB PAGE

Assorted pilot devices

CATALOG LINK

WEB PAGE

Electrification solutions microgrid controller



CATALOG LINK

WEB PAGE

References

(1) A. Mikhaylov, “An overview of the roles of inverters and converters in microgrids,” in *Proc. Int. Conf. Collaborative Endeavors for Global Sustainability*, Jan. 2024, pp. 69–85, doi: 10.1007/978-3-031-53574-1_3.

(2) B. Rodríguez, J. D. Ramos-Paja, and J. D. Bastidas-Rodríguez, “Types of inverters and topologies for microgrid applications.” [Online]. Available: https://www.redalyc.org/journal/5537/553757254001/553757254001.pdf

(3) S. Reichert, G. Griepentrog, and B. Stickan, “Comparison between grid-feeding and grid-supporting inverters regarding power quality,” in *Proc. IEEE 8th Int. Symp. Power Electron. Distrib. Gener. Syst. (PEDG)*, Apr. 2017, pp. 1–4, doi: 10.1109/PEDG.2017.7972536.

(4) W. Ming, “Power electronic converters for microgrids,” IntechOpen eBooks, Dec. 2021, doi: 10.5772/intechopen.101019.

CONTACT US

Do you have a similar project and are you searching for the right application configuration?
Contact us and talk to our experts!

U.S HQ Office:
ABB
305 Gregson Drive
Cary, NC 27511
United States
Phone: (800) 435-7365

electrification.us.abb.com

We reserve the right to make technical changes or modify the contents of this document without prior notice. With regard to purchase orders, the agreed particulars shall prevail. ABB Inc. does not accept any responsibility whatsoever for potential errors or possible lack of information in this document.

We reserve all rights in this document and in the subject matter and illustrations contained therein. Any reproduction, disclosure to third parties or utilization of its contents – in whole or in parts – is forbidden without prior written consent of ABB Inc.

9AKK108471A0427