APPLICATION NOTE

POWER AND CONTROL SOLUTIONS FOR DC/DC CONVERTERS

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 converters.

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 DC/DC converters?
DC/DC converters are power electronic devices that adjust direct current (DC) voltage from one level to another by stepping it up or down, depending on the system's requirements. In microgrid applications, DC/DC converters play a crucial role in interfacing various energy sources with the broader system by ensuring that the voltage levels are compatible and optimized for efficient power flow. These converters are designed to operate with high efficiency to minimize energy losses.

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

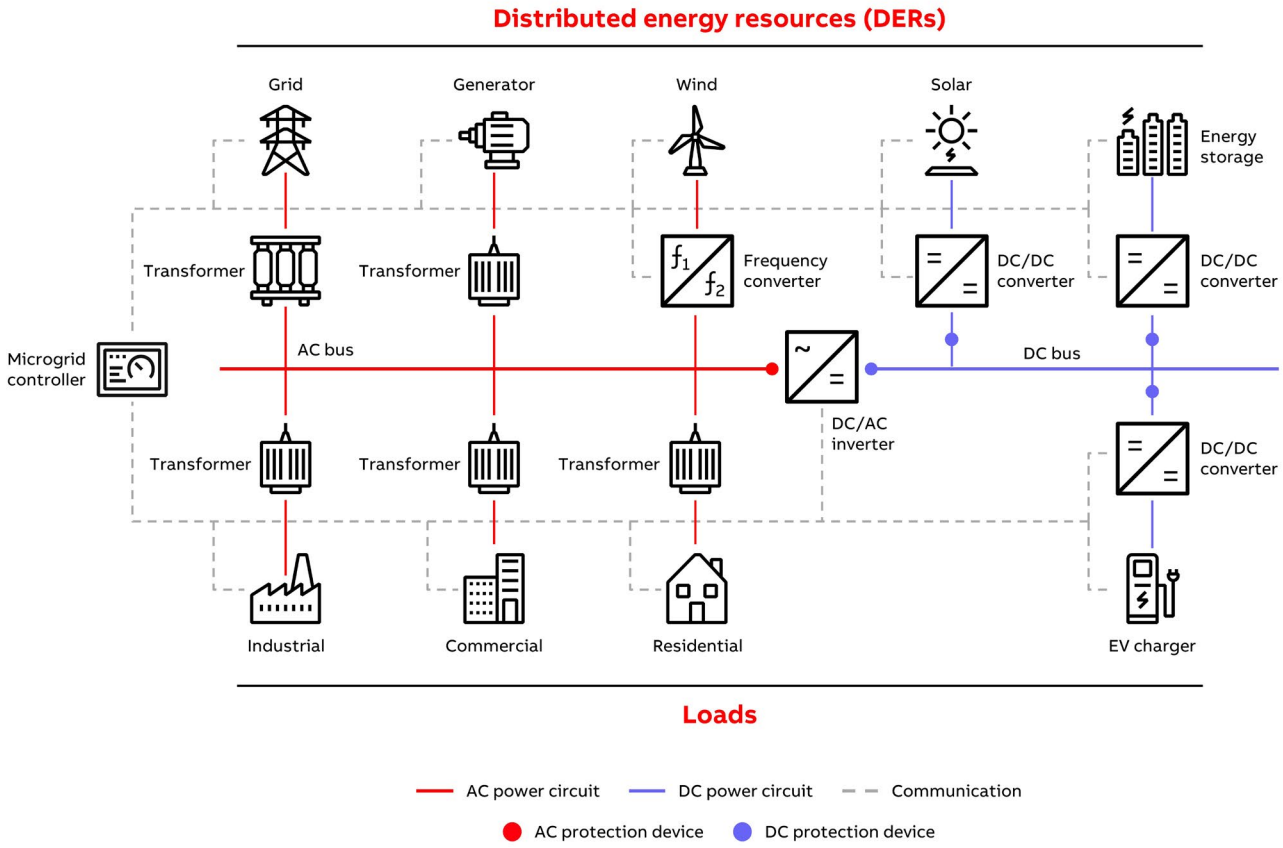
Continuous operation
Our advanced solutions provide superior short-circuit protection and advanced trip units help to enhance system reliability and power quality by identifying voltage instabilities.

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.

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 DC/DC converters are important

DC/DC power converters are electronic devices used to change DC power from one voltage level to another to meet the output requirements of the system. They are one of the critical components in AC and DC microgrids. DC microgrid systems are formed by combining DC/DC power converters on a bus with devices, such as photovoltaic (PV) panels, battery energy storage systems, Level 3 electric vehicle (EV) chargers, and DC loads.

These converters are designed to operate with high efficiency to minimize energy losses, which is important in renewable energy systems where maximizing the utility of available power is essential. In addition to voltage regulation, some advanced DC/DC converters provide isolation, power conditioning, and support for energy management functions within the microgrid.

Some of the roles and benefits of converters in a microgrid system are:

Roles

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

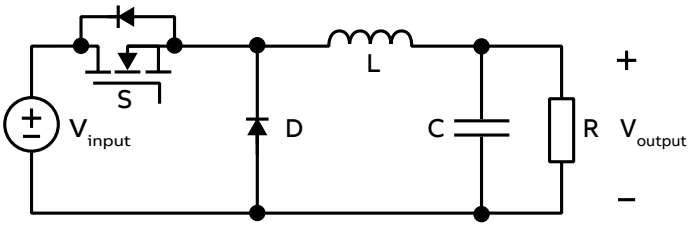
Benefits

- 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
- The transition from simple linear to complex software-driven designs has led to its integration into smart grid systems
- Enables dynamic energy management and real-time response to changing load conditions

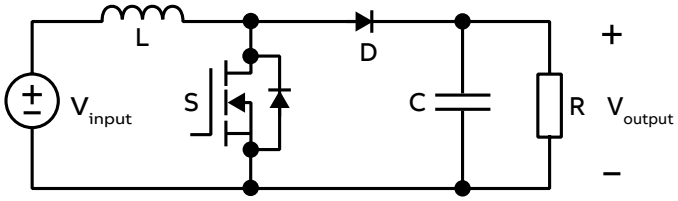
DC/DC converters power circuit topologies

DC/DC converters are used to create higher or lower DC voltages. The systems listed below are designed to maintain a stable DC output without being affected by possible fluctuations of the DC input voltage or the load current. Some examples of DC/DC converters and their applicability are:

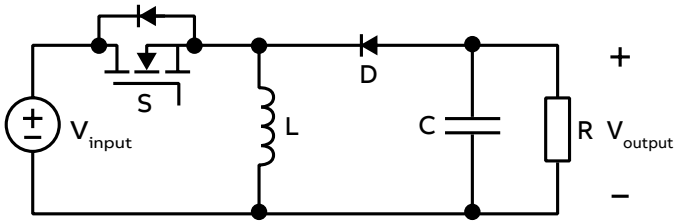
Buck converters
Buck converters are step-down converters used for reducing the input voltage to a lower output voltage. For example, microgrids use a high-voltage 380 V DC bus to tie together solar panels, fuel cells, and batteries. A buck converter drops that voltage down to the lower levels (48 V, 24 V, 12 V, or 5 V) needed by low-voltage components in the microgrid system.



Boost converters
Boost converters are step-up converters used for increasing the input voltage to a higher output voltage. For example, the solar panels' output voltage of around 30 – 100 V is lower than the microgrids' 380 V DC bus. A boost converter with Maximum Power Point Tracking (MPPT) steps the panel voltage up to 380 V and continually adjusts itself to pull the maximum possible power from the panels.



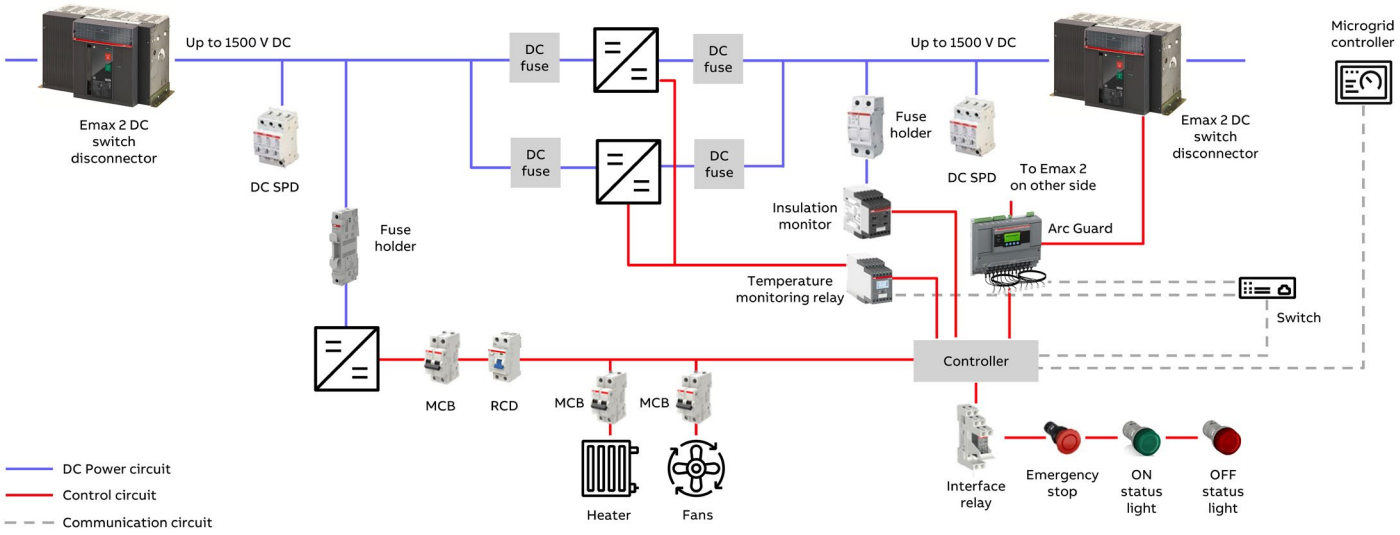
Buck-Boost converters
Buck-boost DC-DC converters combine the step-down (buck) and step-up (boost) functions in one stage, making them suited to microgrids where voltages can be both above and below the DC bus. They are bidirectional converters used to connect a subset of isolated DC/DC converters with equal but not identical voltage levels. For example, in a remote telecom microgrid, a 48 V battery and a small PV panel share the same bus. When the PV voltage falls below 48 V (e.g., in low light), the converter boosts it up to charge the battery; when it rises above 48 V (e.g., in bright sun), the converter bucks it down to prevent overcharging.



Legend

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

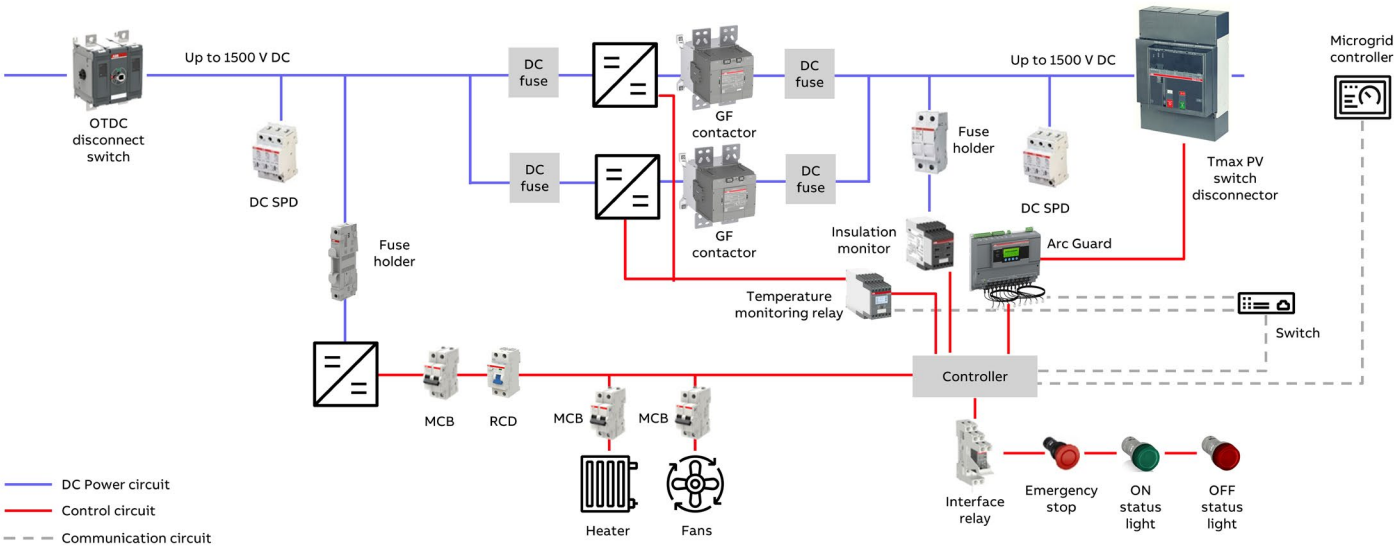
Power and control solutions for LV Utility DC/DC converter



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

Product	Function
Emax 2 DC switch disconnector	For isolation and remote operation
SPD	For protection against overvoltage from the DERs
Arc Guard	For Arc Flash mitigation

Power and control solutions for LV commercial & industrial DC/DC converter



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

Product	Function
OTDC disconnect switch	For isolation
SPD	For protection against overvoltage from the DERs
GF contactor	For switching combined with fuses on each converter branch
Tmax PV switch disconnector	For isolation and remote operation
Arc Guard	For Arc Flash mitigation

Product offering

Emax 2 MS/DC-E switch disconnectors

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Tmax PV MCCBs

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OTDC disconnect switches

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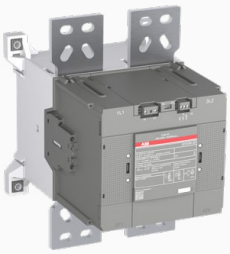
GF contactors



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Surge protection devices

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Fuse holders

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Residual current devices

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Miniature circuit breakers

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Product offering

Measuring and monitoring relays

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Arc Guard Systems

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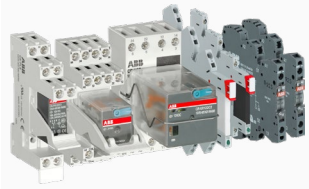
Interface relays and optocouplers



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Assorted pilot devices

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Electrification solutions microgrid controller

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References

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

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

electrification.us.abb.com

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