APPLICATION NOTE

Switching and Protection solutions for 800VAC Recombiners in Photovoltaic plants

UL Utility scale

Are you searching for Switching & Protection solutions to protect and secure your 800VAC Recombiners? Use our pre-configured Application Bundle to rapidly develop Utility-Scale Photovoltaic plants using 1500VDC string inverters.

What is an AC Recombiner?
If you want to connect several string inverters in parallel prior to connecting to an MV/LV transformer you need an AC Recombiner. AC Recombiners are outdoor switchboards where switching and protection devices are installed along with auxiliary and/or communication circuits.

Why you need a Switching & Protection solution for AC Recombiners
Every inverter output circuit (“feeder”) requires a UL listed disconnecting means and accompanying overcurrent protection.
AC recombiners are also frequently provided with a main circuit breaker for MV transformer secondary protection.

Main benefits

Smarter protection
Increase power in your installation and reduce CAPEX using our full range of LV components up to 800VAC and 1500VDC for excellent performance in harsh outdoor environments.

Speeds up your projects
Accelerate project development and deployment thanks to preconfigured bundles comprising a coordinated range of products in compact sizes.

Safety
Reduce the risk of property damage, fire, and electric shock using our comprehensive range of protective devices, including disconnects, breakers and Surge Protection Devices (SPDs).

Smarter metering and monitoring
Maximize your operations and increase plant yields with supplemental measurement and monitoring devices.

Main trends in string inverter architecture

Virtual Central Inverter

A single MPPT maximizes the energy from the strings. The inverter is capable of maximizing for one value of DC current and is therefore ideal for homogeneous photovoltaic plants. The architecture behaves similarly to a central inverter photovoltaic plant DC combiner boxes are required.

Highlights
- Reduced installation costs and time
- Ease of installation (specialized electricians are not required)
- Perfect on hilly ground and rugged land plots that are difficult to access
- Connection and feed-in to the grid are faster and more progressive
- Easy to service and replace.

Multi-MPPT String Inverters

Multi-MPPT inverters improve total energy production when the PV generator features an asymmetric string configuration and shading is not uniform.
Multi-MPPT inverters are typically designed for higher AC voltage ratings and achieve cost savings involving the whole system.

Highlights
- Increased plant flexibility and efficiency
- Eliminates DC combiner boxes and DC source circuit fusing
- Simpler design using AC low-voltage distribution
- Fewer total components: PV panels + solar inverters + MV/LV compact substation (CSS).

800VAC Reduces BoS Cost

Higher inverter output voltages, up to 800VAC, make the whole system more efficient, especially for string inverter architecture where the cables between the inverters and MV/LV transformer are usually very long.

Highlights
- 40-50% savings on AC cables and components compared to 480VAC string inverters
- AC conductors do not need the additional 1.25 derate factor that [DC] PV source and output circuits require
- 100% UL rated 489 800VAC MCCBs do not require the 1.25 derate factor which helps reduce conductor size
- Using higher DC:AC ratios can increase nominal capacity utilization (FLA) of the inverter output circuit conductors.

More Watts, Same Volume

Fewer inverters can be used at 800VAC due to their greater power density (W/m^3). While remaining compact, this enables fewer, but larger amperage circuits in the PV plant In addition, a wide range of inverter output circuit sizes is supported by ABB.

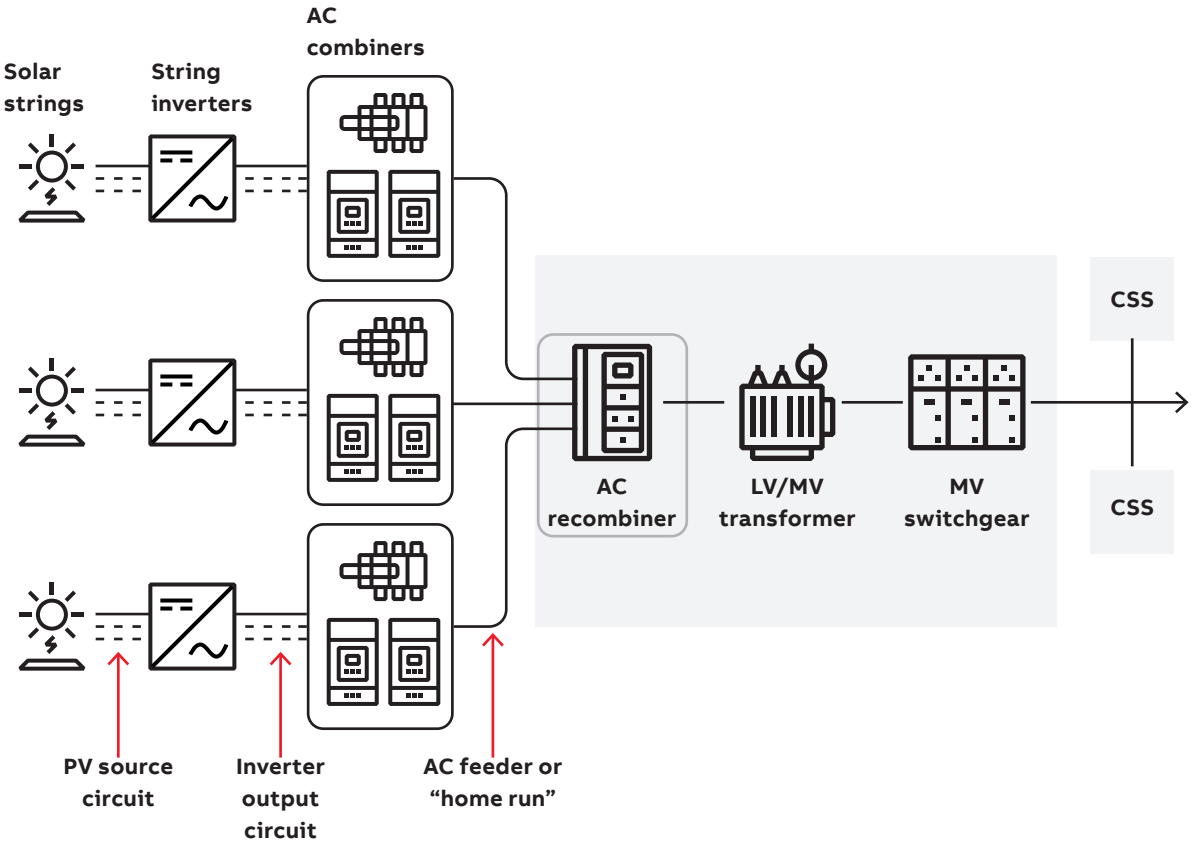
Typical features
- DC input voltage: 1500VDC
- AC output voltage: 800VAC
- 100-275kW (333kW soon)
- Output currents: 70-200A
- AC protection nominal current: 80-300A
- AC circuit protection: breaker, fuse + disconnect
- Certifications: UL, IEC, CCC.

AC Recombiners in String inverter architecture

Fundamentals, main components & functionalities

The power generated by solar strings is converted to AC by each string inverter and collected by the AC Recombiner. The recombiner is a rugged, outdoor-rated switchboard where many string inverter output circuits (feeders) are connected in parallel.

Every feeder circuit requires a disconnect means and overcurrent protective device.



AC recombiner components

- Main circuit breaker for transformer protection
- AC switching and protection devices (MCCB, or disconnect + fuse) for feeder protection
- Insulation monitoring device for detection of ground faults
- Surge protective device (SPD) for safely managing overvoltage
- Auxiliary circuits.

Optional components for AC recombiners

- Arc flash mitigation: Active, Passive or Preventive solutions
- Temperature monitoring relay.

Primary Functional Requirements

- Combining of inverter output circuits
- Overcurrent protection (OCPD) for inverter output circuit
- Disconnecting means and circuit isolation for ungrounded, non-isolated PV inverters
- Main circuit breaker to protect transformer secondary and to isolate PV plant from grid voltage (such as a PV System Disconnect)
- Surge Protection against voltage spikes, caused by switching or indirect lightning strikes for example.

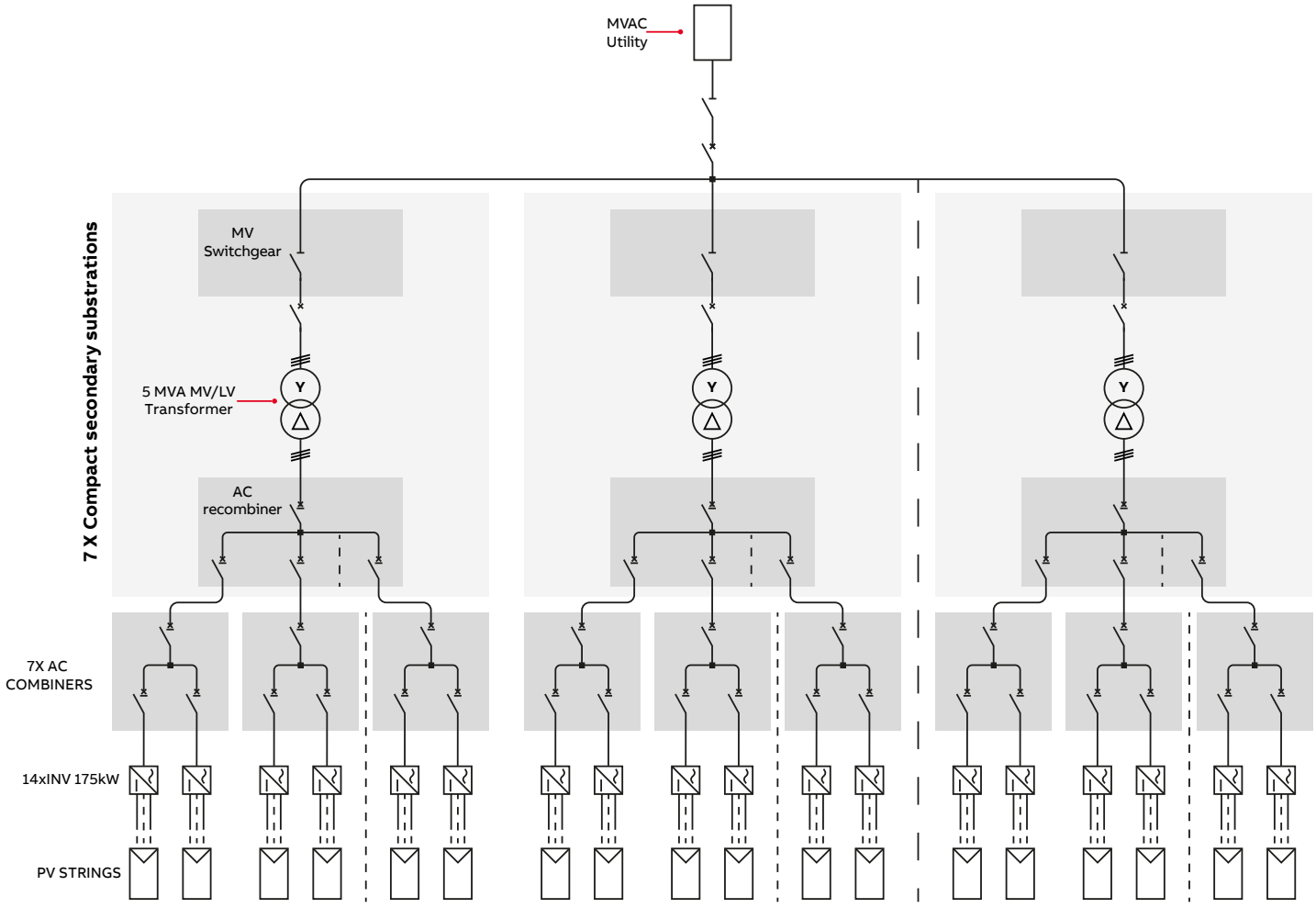
Secondary Optional Requirements

- Monitoring: where any drop in PV plant performance may represent a significant economic loss
  - Voltage, current or temperature monitoring
  - Communication: for communicating parameters to centralized monitoring system
- Remotely-operated: when remote control is required
- Arc flash detection and interruption to reduce the likelihood of property damage or personal injury
- Provide supplemental detection of first ground fault in AC output circuits using insulation resistance monitoring relay

Switching and Protection Solutions for 800VAC Recombiners in Utility scale Photovoltaic plants

Discover our Switching & Protection solutions for 800VAC recombiner configuration considering an 18MW Photovoltaic plant with 7 compact secondary substations each comprising 14 x 175kW string inverters.

Single-line diagram of 18 MW plant utilizing 7 compact secondary substations (1 CSS = 1 recombiner + 14x 175kW string inverters)

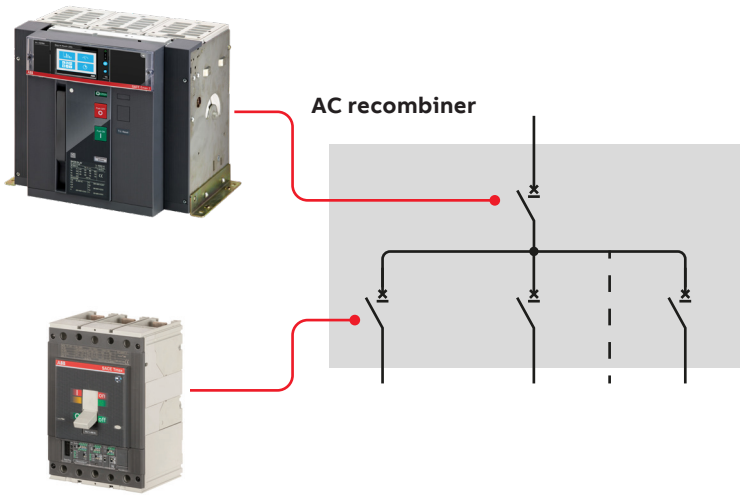


Specifications of system electrical quantities

Input data	UL
Rated power of system [MW]	18 (17.2)
MV/LV transformer rated power [MVA]	2.5 (wye-delta)
N. Compact SubStations (CSS)*	7
Inverter rated power [kW]	175
N. inverters per AC combiner	2
N. AC combiners per CSS	7
N. AC recombiners per CSS	1
Rated DC voltage [V]	1500
Rated MVAC voltage [kV]	15
Rated LVAC voltage [V]	800
Rated LVAC inverter current [A]	127
Rated LVAC recombiner feeder current [A]	254
Rated LVAC bus current [A]	1778
Short circuit current LVAC bus [kA]**	36
Short circuit current LVAC feeders [kA]	40

* While string inverter systems are more common in plants totaling less than 5MW,AC, the 2.5 MW compact substation can be used and duplicated, from 2.5 MW to 5 MW and beyond, depending on the user's specific system requirements.
** short circuit current is site specific and determined by the fault contribution from all sources, such as PV panels (non-isolated inverters), PV inverters, and the MV/LV transformer. It is the responsibility of the user to consider all sources of fault current, in addition to factors such as cable impedance, to ensure that equipment and device short circuit current ratings are not exceeded.

ABB offering (UL)



Main components
ABB Emax 2 E2.2S E/9 2000 Ekip Touch LSIG FVR 3p + Ekip Measuring package main circuit breaker fixed version In=2000A for protection and isolation, equipped with Ekip com Modbus TCP communication module and with YO/YC and motor to open/close remotely. IEC-only***
ABB Tmax T5X-HA400UL PR221DS-LS/I IN300 3P FF feeder circuit breaker with LS/I IN=300A + auxiliary contacts + shunt trip for external control **OR** **ABB Tmax T5X-HA 400 UL TMA 300-3000 3p FF** feeder circuit breaker fixed version In=300A + auxiliary contacts for protection and isolation.
ABB OVR T2 3L 40-440 P TS U + OVR T2 40-440 P TS U connected in series for protection up to 800V AC under UL 1449 4th edition

Optional components
ABB CM-IWM.11 Insulating monitoring relay to detect first ground fault in ungrounded AC systems even with large leakage capacitance. IEC-only***
ABB CM-TCN.011S temperature monitoring relay to measure temperature inside recombiner

*** For components labeled "IEC-only," additional work must be done to ensure conformance to applicable UL standards, and/or acceptance by a local AHJ. Otherwise, these components may be omitted from the design.

Bill of materials

Parameters considered	
18 MW 800VAC string inverter PV plant	1x recombiner per CSS
7x 2.5 MW compact secondary substations (CSS)	14x 175 kW 800VAC string inverters per recombiner

Main Components

Device	Part number	US Product Code	Quantity per CSS	Total quantity
E2.2S/E9 2000 EKIP TCH LSIG 3P FHR 900V	1SDA104324R1	1SDA104324R1	1	7
Measuring package for Emax 2	1SDA107525R1	1SDA107525R1	1	7
Motor-M E2.2 24-30V AC/DC	1SDA073722R1	ZEBM2	1	7
YO E1.2..E6.2 24V AC/DC	1SDA073668R1	ZEASA	1	7
YC E1.2..E6.2 24V AC/DC	1SDA073681R1	ZEACA	1	7
Ekip Supply 24-48V DC	1SDA074173R1	ZEAPWRSD	1	7
Ekip Com Modbus TCP	1SDA074151R1	ZEAMODTCP	1	7
T5X-HA 400 UL TMA 300-3000 3P 800V	1SDA104664R1	T5P8Q300TW	7	49
T5X-HA400UL PR221DS-LS/I IN300 3P F	1SDA104666R1 (alternate)	T5P8XQ300BW	0	0
AUX-C 3Q 1SY 24V DC	1SDA054915R1	KT5AS3-AU	7	49
OVR SPD 3P 40KA 440V P TS 3RD ED + SPD, OVR, 40KA, 440V, PLG, W/AUX, 3RD ED	2CTB802345R2900 + 2CTB802341R2900	OVRT23L40440PTSU + OVRT240440PTSU	1 + 1	7 + 7

Optional Components

Device	Part number	US Product Code	Quantity per CSS	Total quantity
RELT Ekip Signalling 2k-3	1SDA074169R1	ZEB2K3	1	7
TVOC-2 ARC monitor 24-48 C/W COM	1SFA664001R1004	TVOC-2-48-C	1	7
Current sensing unit	1SFA664002R5001	CSU-2LV	1	7
Fibre-optic detector TVOC-2, 2M	1SFA664003R1020	TVOC-2-DP2	1	7
Monitor to CSU cable 2 meter	1SFA664004R1020	TVOC-2-OP2	1	7
CM-TCN.011S TEMP MON RLY LCD+NFC	1SVR750740R0110	CM-TCN.011S	1	7
CM-IWM.11 (Insulation resistance monitoring relay)	1SVR470670R1100	CM-IWM.11	1	7

APPLICATION FINDER

We've made it simpler for you to set up your project!
Click here to find the reference architecture that best fits your needs and download the Bill of Materials.

Product offering

Emax 2 E/9 (IEC-only):

WEB PAGE

CATALOG

Tmax HA 800VAC:

WEB PAGE

CATALOG

OVR SPDs:

WEB PAGE

CATALOG

CM-IWM (IEC-only):

WEB PAGE

CATALOG

Arc Guard TVOC-2:

WEB PAGE

CATALOG

To discover more

APPLICATION FINDER

Find the reference architecture tailored to your needs and speed up your project thanks to our new Application Finder Tool!

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