



Overview on Wiring of Hybrid Solar PV Systems





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Solar PV array wiring

DC PV Cable Specifications

- Information on voltage and temperature range, bending radius, approvals
- Former identifier PV1-F: most suitable for normal PV installation, but not for permanent laying in water or soil.
- New identifier H1Z2Z2-K: also, for permanent laying in water or soil
- Consider additional UV protection for SA

Photovoltaic cables - Solar EN50618 H1Z2Z2-K 1/1 kV ● fire behaviour - Dca - s2, d2



Technical attributes

Standards	EN 50618
Conductor material	Cu, tinned
Conductor type	flexible
Conductor standard	DIN VDE 0295/IEC 60228
Conductor category	5
Core insulation	halogen-free, cross-linked polymer
Core colours	light grey
Outer sheath	halogen-free, cross-linked polymer
Outer sheath colour	black - red - blue
Temperature range min.	-40 °C
Temperature range max.	+90 °C
Temperature at conductor max. (20.000 h)	+120 °C
Nominal voltage U ₀ /U	1,0/1,0 kV (AC)
Test voltage	6,5 kV (AC)
Max. voltag U _m	1,8 kV (DC)
Minimum bending radius, fixed installation	5 x cable-Ø
Fire behaviour	Dca - s2, d2
RoHS-compliant	ja

PV String Sizing Considerations

- Maximise string V_{oc} , but never exceed inverter/charge controller maximum input voltage (At coldest conditions, $V_{oc} \times 1.15$)
- Ensure V_{mpp} is high enough to switch on and produce power at hottest conditions ($V_{mpp} \times 0.8$).
- Ensure all DC components are rated for DC and maximum expected V_{oc}

DC Interconnections

- Preferably correct colour coded cables
 - **Red** - Positive
 - **Black/Blue** – Negative. If not;
- Must be labelled with positive and negative on both ends.
- **DC** Connector plugs (MC4, SUNCLIX or other DC rated connectors).
- All DC connections and conduction sections should be **enclosed** and/or **insulated**.
- **NEVER** disconnect PV module connectors or other associated PV wiring when it is under load.
 - Proper DC disconnection devices should be used or
 - Disconnection should take place at night

DC Interconnections

Very Important!

- Double check for loose connections
- Ensure not fixed on insulation
- Use Pin-lug or Bootlace ferrules if DC connectors like MC4 cannot be used.

DC Interconnections



Note: Position as well

DC Interconnections



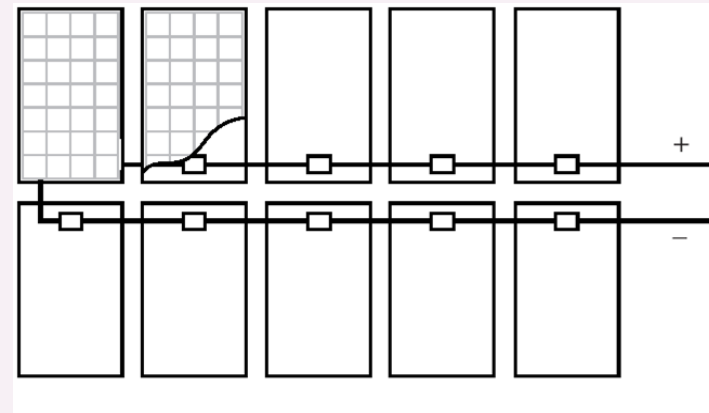
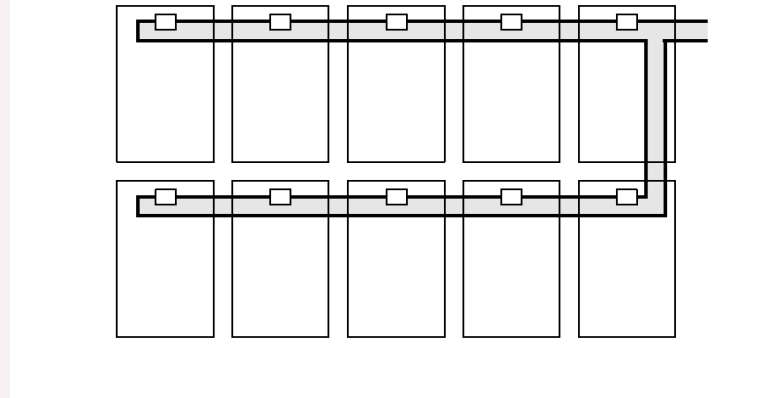
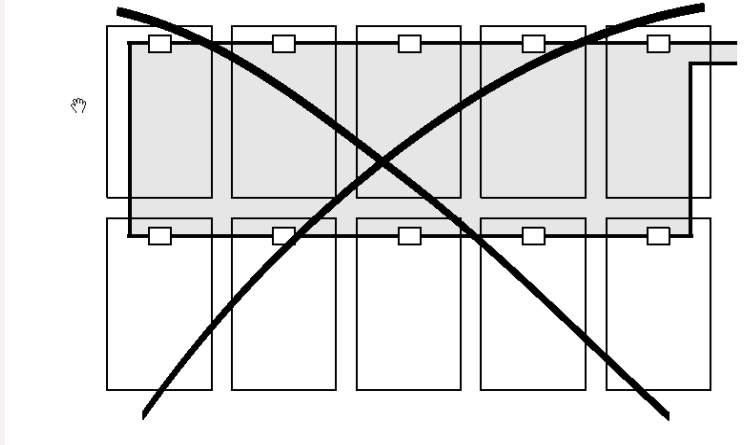
DC Cables/Wires

- Must be **rated** for **DC** and **1000V-1500V**
- Each string should be fused with a **DC rated fuse** only for three strings or more connected in parallel.
- Recommended cables exposed to the environment should be **enclosed/protected**
- Recommend to use steel straps or at least **UV protected (weatherproof) cable ties**
- Cables to be protected from **sharp bends** and **edges**



Cable Routing

Cable routing



BETTER!

Overvoltage induced into cables is minimized AND

Cable length is optimized

Upside-down module orientation must be approved by the module manufacturer

Cable routing (SANS 60364-7-712)

IEC CD 60364-7-712 © IEC 2021

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64/2514/CD

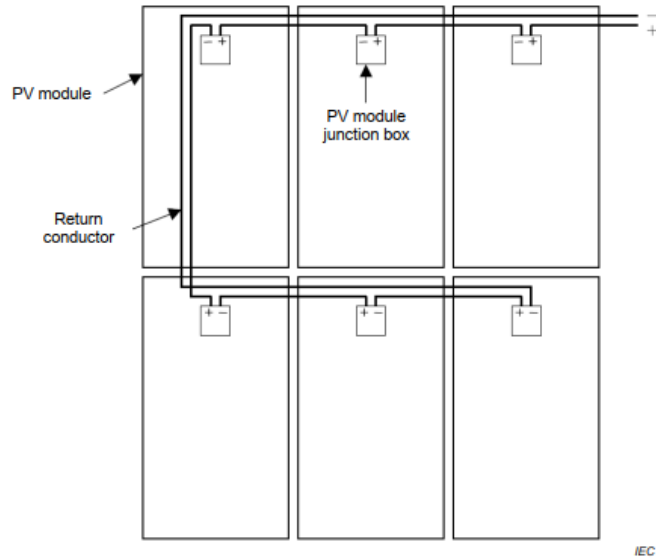


Figure 15 – PV string wiring and DCU string wiring with minimum loop area

712.521.103 Wiring loops

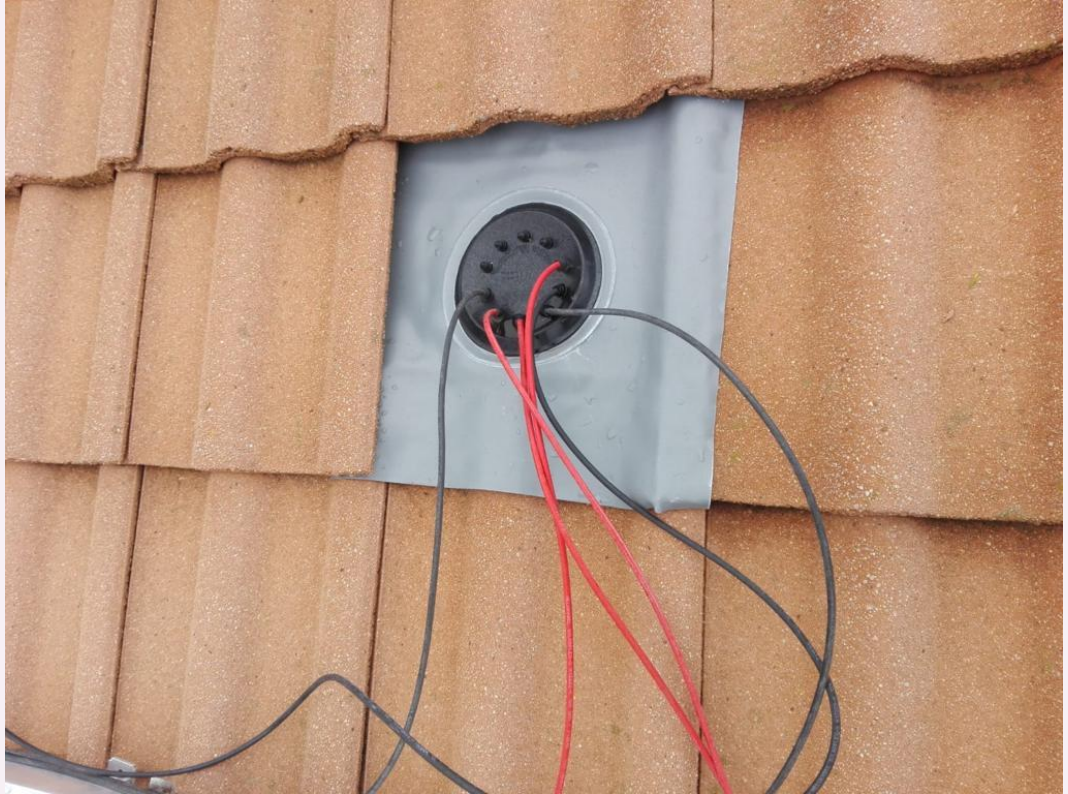
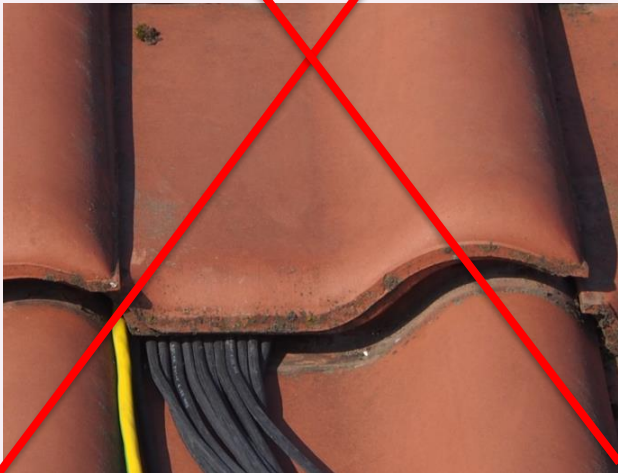
To reduce the magnitude of transient overvoltages and EMC interference with other installations, the DC side wiring shall be laid in such a way that the area of conductive loops is minimized (e.g. by laying cables in parallel as shown in Figure 15)

Outside Cable Laying

- Module cables and connectors must not lie on the roof
- For roof-parallel systems, the cables are usually not accessible after the modules have been mounted
- Fastening points can be created by brackets/clips for sliding on the module frame



Incorrect Cable routing

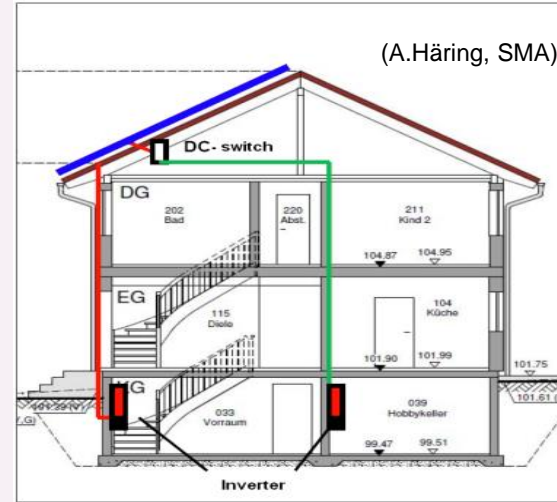
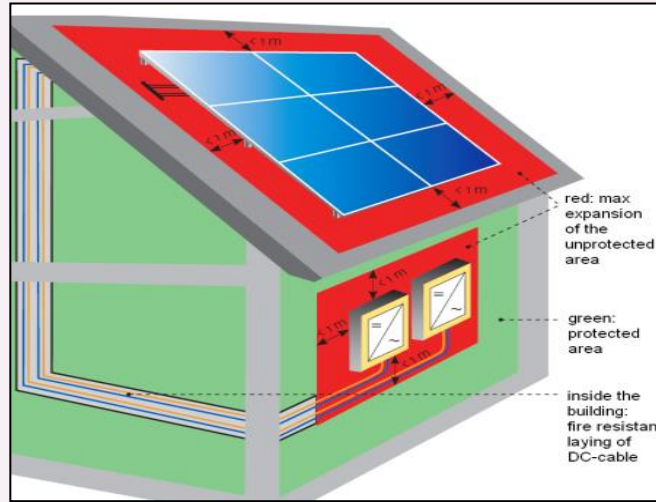


Inside Cable Laying

- Strain-relieved cable laying
- Observe fire protection
- Cables and other components should be clearly marked
- Separation between AC and DC in trunks
- Parallel laying of data cable may cause data interference



Overall Safety and Fire Prevention of a Solar PV Installation



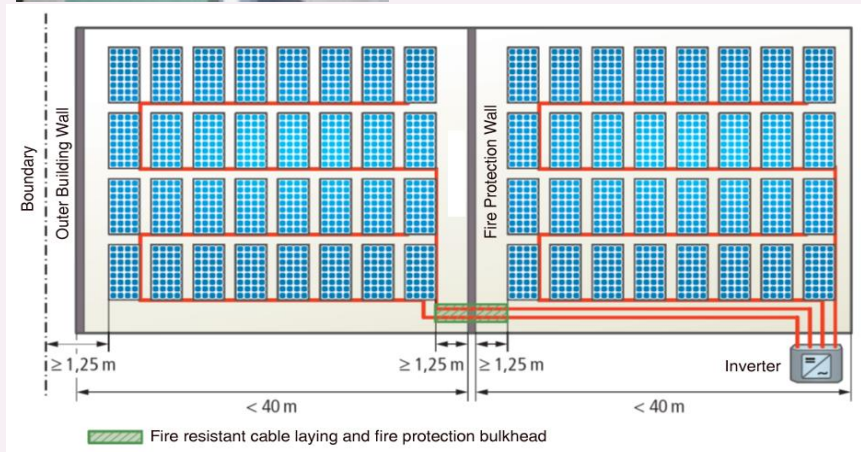
- Inside the building cables must be isolated in case of fire or laid out in a fire-resistant way
- Around PV Array and inverter, 1m must be regarded as unprotected

Overall Safety and Fire Prevention of a Solar PV Installation

- Use of fire-resistant conduits
- DC cables outside the building
- Inverter mounted outside (sheltered installation recommended)



Overall Safety and Fire Prevention of a Solar PV Installation



- Consider fire compartments
- Only protected cable laying while crossing fire protection walls
- Modules and unprotected cables: keep distance to fire protection walls and boundaries
- Elevated modules: 1,25m both sides
- Roof parallel 0,50m



Battery Cables

Battery Installation: Cable Sizing

To determine the battery Cable size, the following needs to be determined:

1. What is the battery system voltage?
2. What is the distance between the batteries and the inverter/charger?
3. What is the maximum current the batteries will deliver (Maximum inverter current draw) under normal operation?
4. What is the maximum expected charging current?
5. Size cable according to maximum expected current taking power loss (less than 1%) into account. (Use Cable Excel Tool)

Correct Torques

Result of a connection
With incorrect torque



The plastic part is already melted by high currents, because the surface of the screw was overheated.

Incorrect Parallel Connection

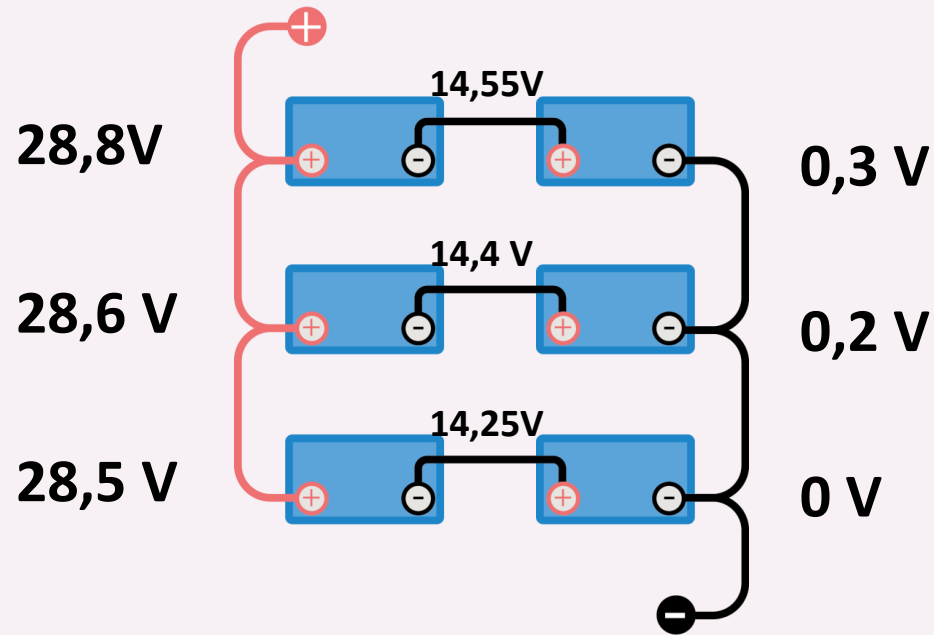


Figure 1: Battery assembly (Schrack technic 2016)

Correct Parallel Connection

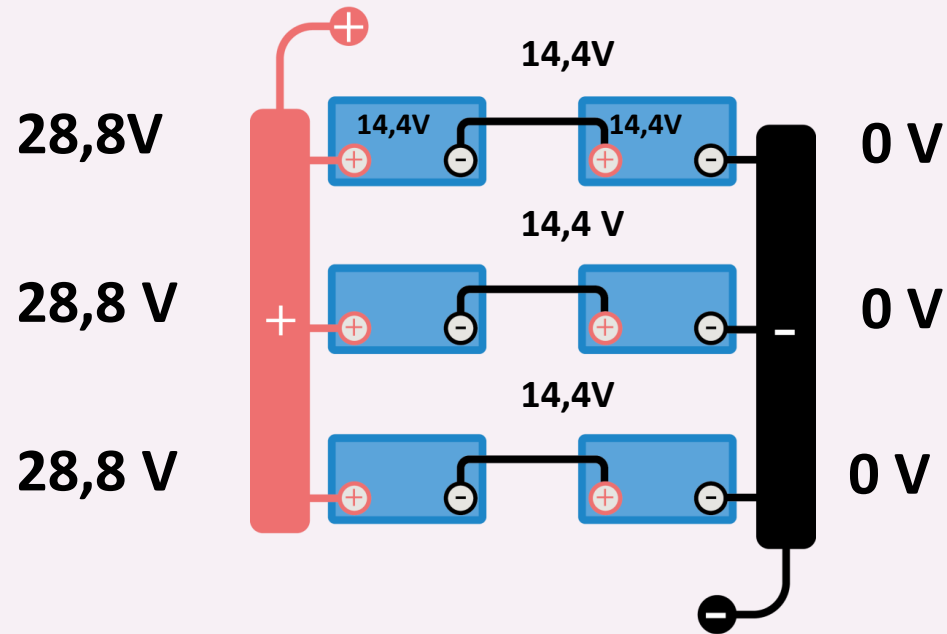


Figure 2: Battery assembly (Schrack technic 2016)

Other battery cabling considerations

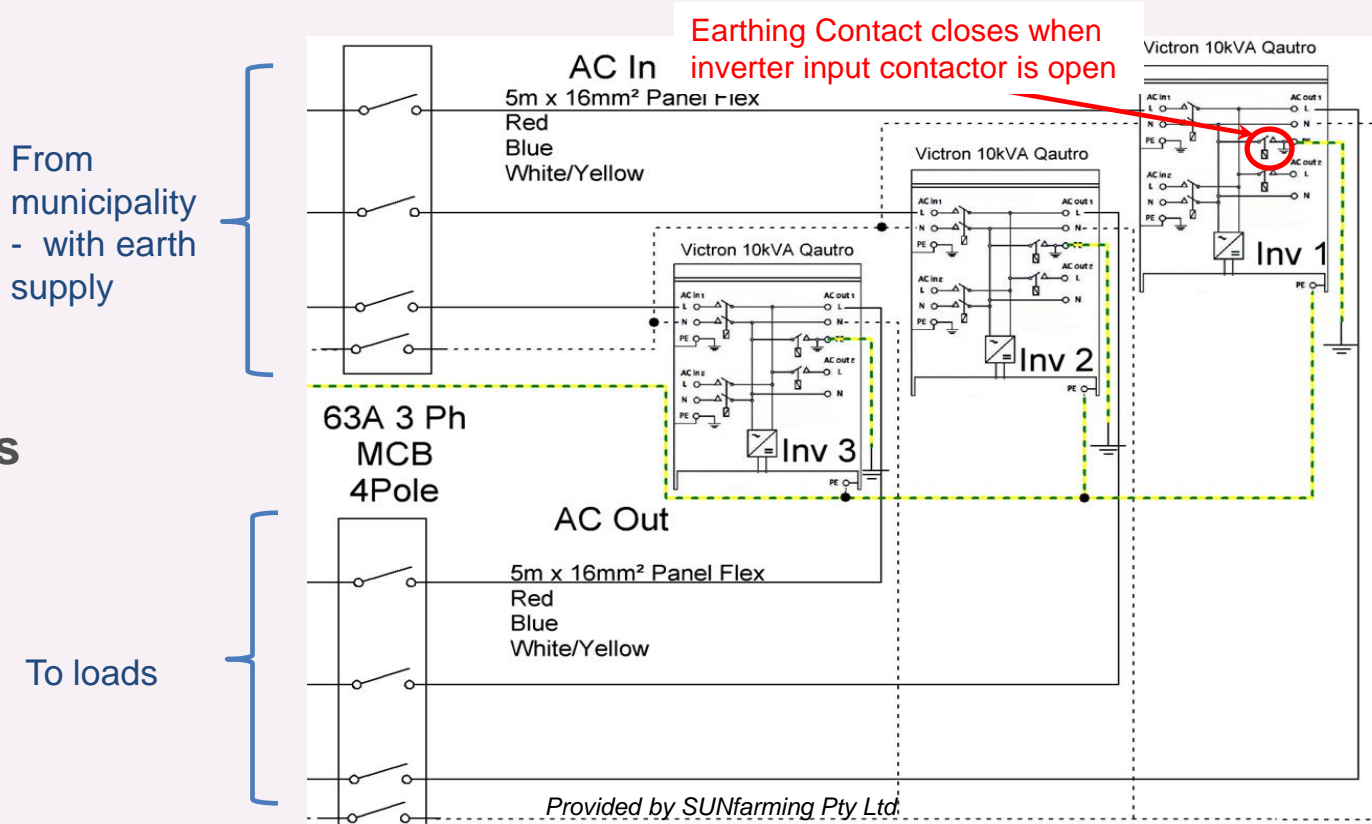
- Communication between batteries and inverter
- Make sure batteries are on the same SOC when connected (especially when expanding batteries)
- Consider number and size of +/- terminals on the battery



PEN for Neutral

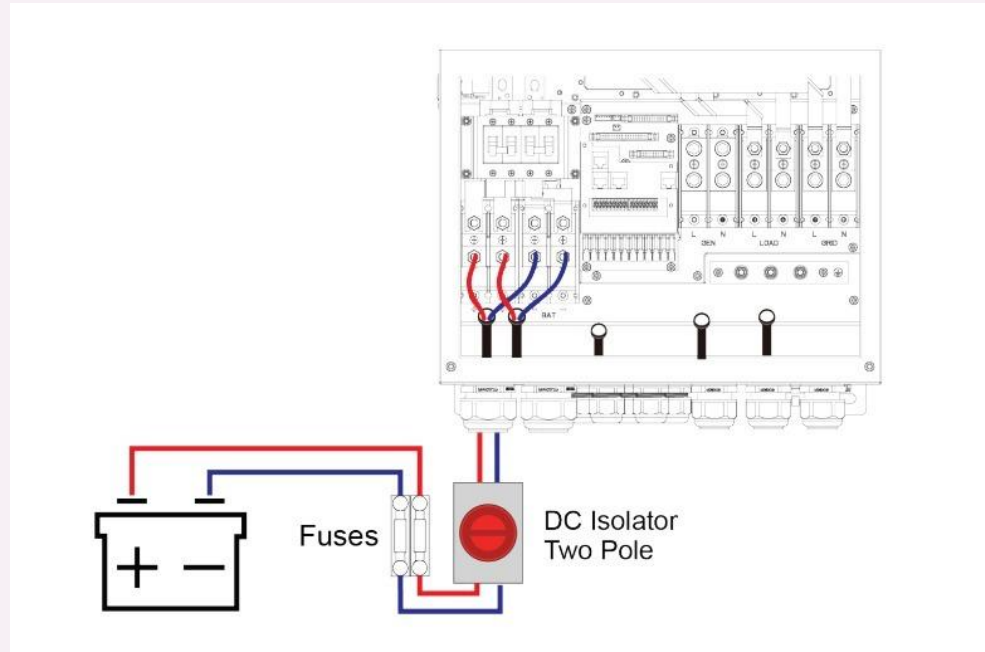
PEN for Hybrid Inverter Example

Earthing Requirements



Additional Considerations for Hybrid Systems

- Cable size when connecting inverters in parallel
- Multiple connection points for larger inverters



Additional Considerations for Hybrid Systems

- Cable size when connecting inverters in parallel
- Multiple connection points for larger inverters
- 4 Core Cables not good practice
- Earth Leakage (RDC) to be installed after inverter output
 - Nuisance tripping is a possible indication of an installation/wiring fault
- Only consider NRS 097-2-1 certified inverters when connected to grid (even if only temporarily). Get inverter system registered with local supply authority

Fresh of the press:

NRS 097-2-3:2023

Edition 2

GRID INTERCONNECTION OF EMBEDDED GENERATION

PART 2: SMALL-SCALE EMBEDDED GENERATION

SECTION 3: SIMPLIFIED UTILITY CONNECTION CRITERIA FOR LOW-VOLTAGE CONNECTED GENERATORS

This document is not a South African National Standard

Additional Considerations for Hybrid Systems

Table 1 — Maximum individual installation limits in a shared LV (400 V/230 V) feeder

1	2	3	4	5
No. of Phases	Service CB [A]	MEC = 0.25 UIC [kVA]	NPR = UIC [kVA]	MCC @ 0.25 UIC (per phase) [A]
1	40	2.3	9.2	10
1	60	3.45	13.8	15
1	80	4.6	18.4	20
3	40	7	28	10
3	60	10	41	15
3	80	14	55	20
3	100	17	69	25
3	125	22	86	31
3	150	26	104	38
3	175	30	121	44
3	200	35	138	50
3	225	39	155	56
3	250	43	173	63
3	275	47	190	69
3	300	52	207	75
3	325	56	224	81
3	350	60	242	88
3	375	65	259	94
3	400	69	276	100

Table 2 — Maximum individual installation limits in a dedicated LV (400 V/230 V) feeder

1	2	3	4	5
No. of Phases	Service CB [A]	MEC = 0.75 UIC [kVA]	NPR = UIC < 1MVA [kVA]	MCC @ 0.25 UIC (per phase) [A]
3	125	65	86	31
3	150	78	104	38
3	175	91	121	44
3	200	104	138	50
3	225	116	155	56
3	250	129	173	63
3	275	142	190	69
3	300	155	207	75
3	325	168	224	81
3	350	181	242	88
3	375	194	259	94
3	400	207	276	100
3	500	259	345	125
3	630	326	435	158
3	800	414	552	200
3	1000	518	690	250
3	1250	647	863	313
3	1500	776	999	375

Additional Considerations for Hybrid Systems

Table 1 — Maximum individual installation limits in a shared LV (400 V/230 V) feeder

No. of Phases	1	2	3	4	5
	No. of Phases	Service CB [A]	MEC = 0.25 UIC [kVA]	NPR = UIC [kVA]	MCC @ 0.25 UIC (per phase) [A]
1	40	2.3	9.2	10	
1	60	3.45	13.8	15	
1	80	4.6	18.4	20	
3	40	7	28	10	
3	60	10	41	15	
3	400	69	276	100	
3	1000	518	690	250	
3	1250	647	863	313	
3	1500	776	999	375	

/230 V) feeder

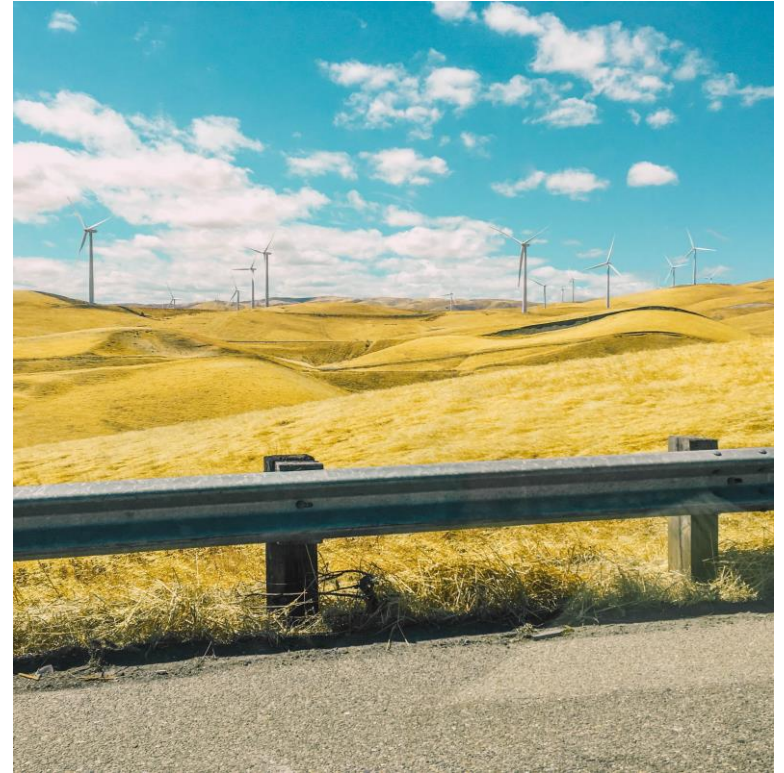


Take Home Messages

TAKE HOME MESSAGES

A few points to remember

1. Specific cables for DC to be used and installed in certain ways
2. Behaviour of DC is different and extra considerations should be made
3. Neutral to be isolated for all solar PV generation. Ensure PEN for Hybrid
4. NRS 097-2-3 allows for larger EG, but limited Charge and Export





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