gasunie
crossing borders in energy

Groningen, 23 september 2020

Zonneparken en stalen leidingen

Beïnvloeding van Kathodische Bescherming met groene stroom.

Henk Horstink

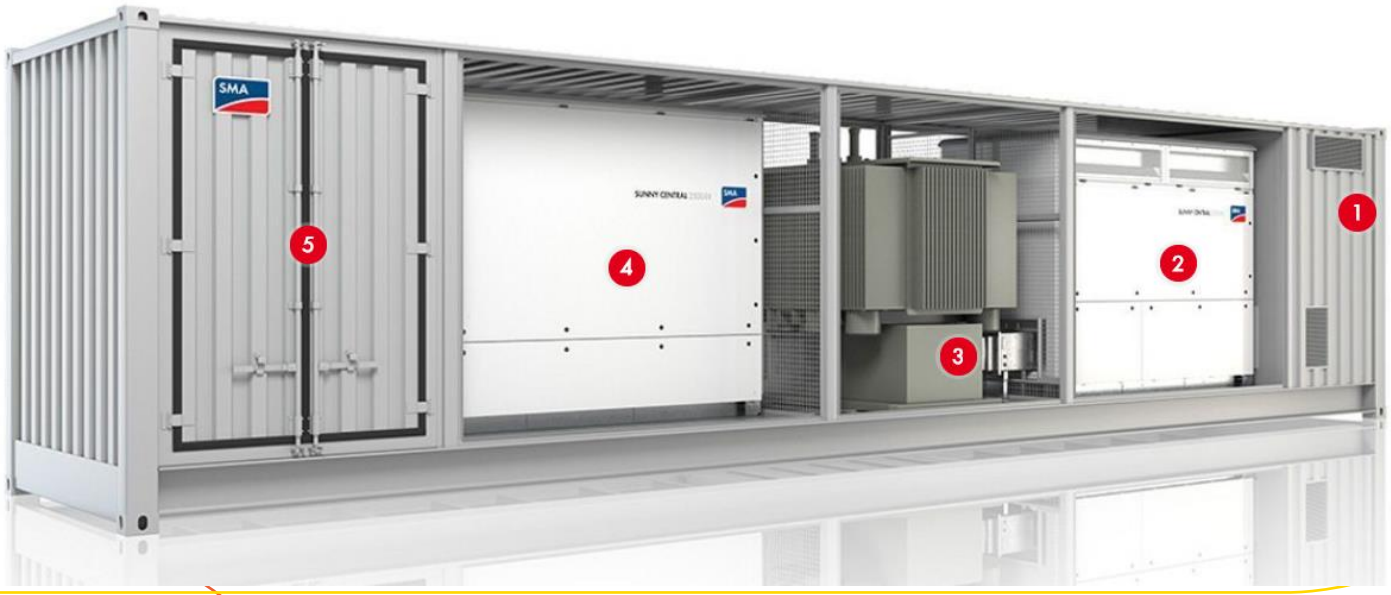
agenda

- **Historie**
- Beïnvloedingsvormen
- Criteria
- Maatregelen
- Hoe verder

I.v.m. Teams
Ruimte voor vragen na elk agendapunt

Historie

- 2017 vragen vanuit tracé beheer.
- 2018 Solar Solutions international
- 2019 Contact met Enduris
- Ceocor 2019 => Universiteit van Cyprus: Charalambos Charalambous
- Voorwaarden voor grondgebonden parken
- Nieuwe ISO-21857 zwerfstroombeïnvloeding noemt nu PV
- 1e bijeenkomst enkele leidingeigenaren en adviesbureaus in 2019



agenda

- Historie
- **Beïnvloedingsvormen**
- Criteria
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- Hoe verder

Benamingen

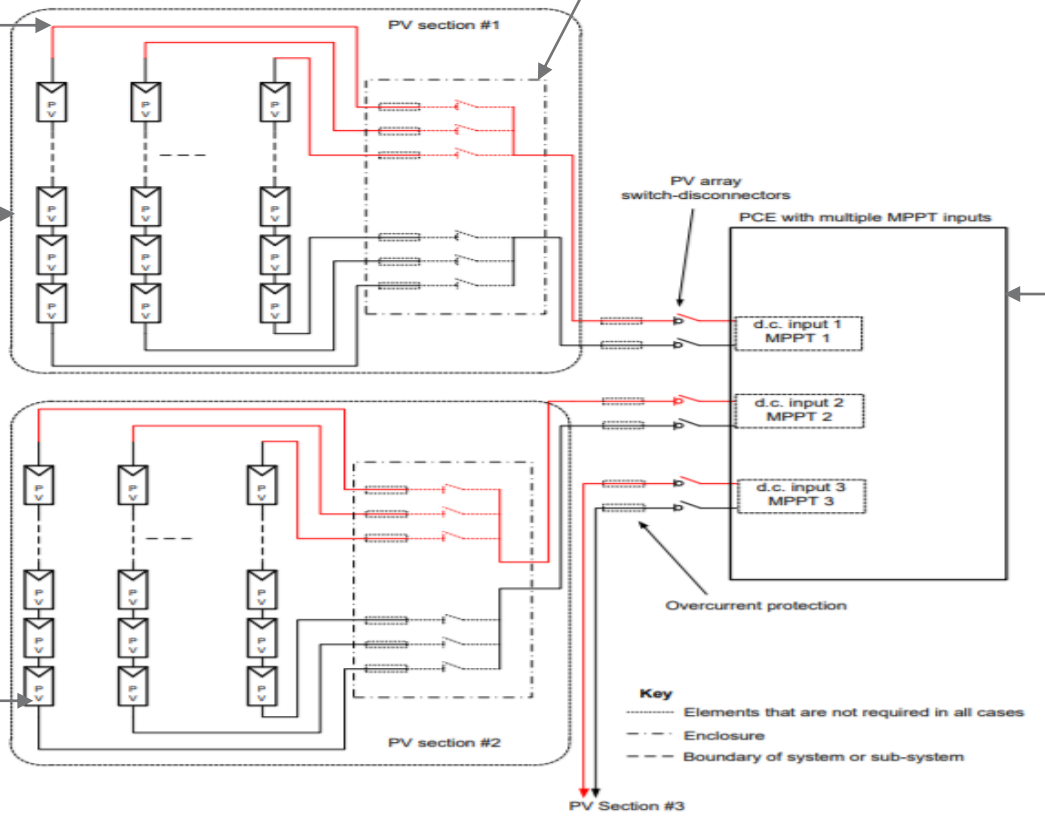
Combiner box

string

array

Omvormer inverter

Zonnepaneel

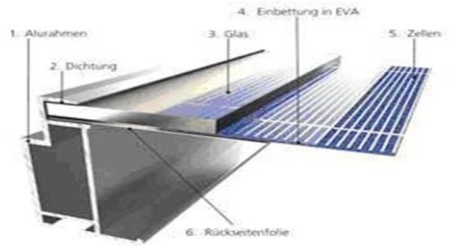


SOURCE: IEC 62548

Figure 2 – PV array example using a PCE with multiple MPPT d.c. inputs

Beïnvloedingsvormen

- DC
  - Lekken van panelen naar aarde
  - Lekken van kabels naar aarde
  - Lekken vanuit omvormers naar aardsysteem



- AC
  - NEN3654: Koppeling van MS/HS aarde naar zonnepark

Aanraakspanning- en brandbeveiliging vanuit de omvormer: R-ISO en RCD/RCMU

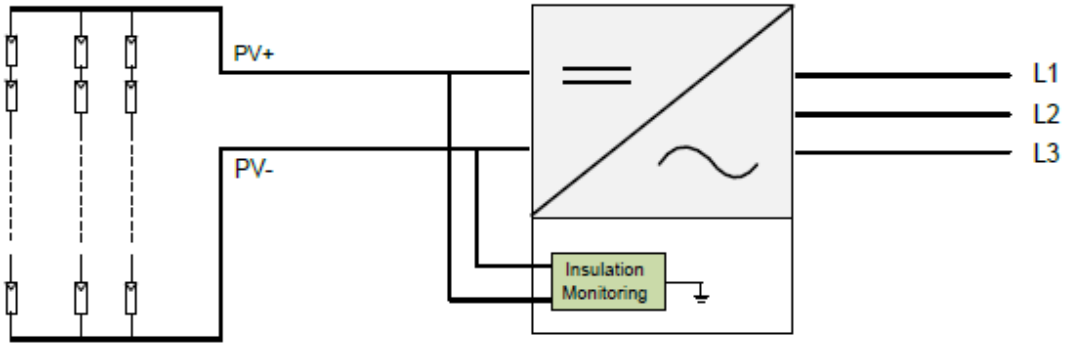


Fig-1 Inverter Insulation Resistance Monitoring

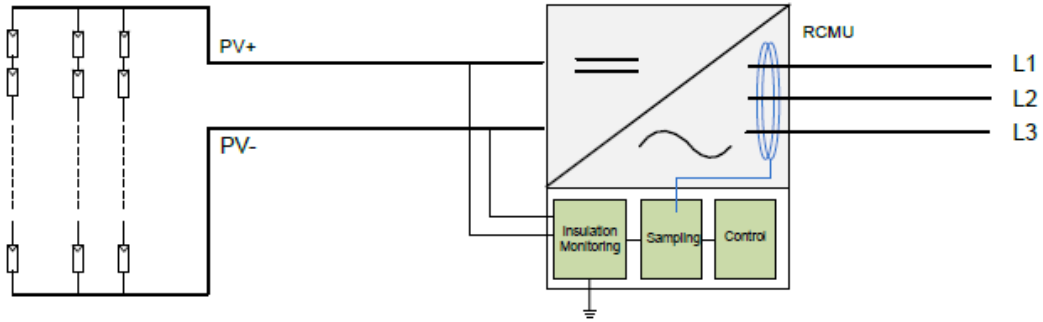


Fig-2 Residual Current Detection

DC isolatie bewaking: R-ISO

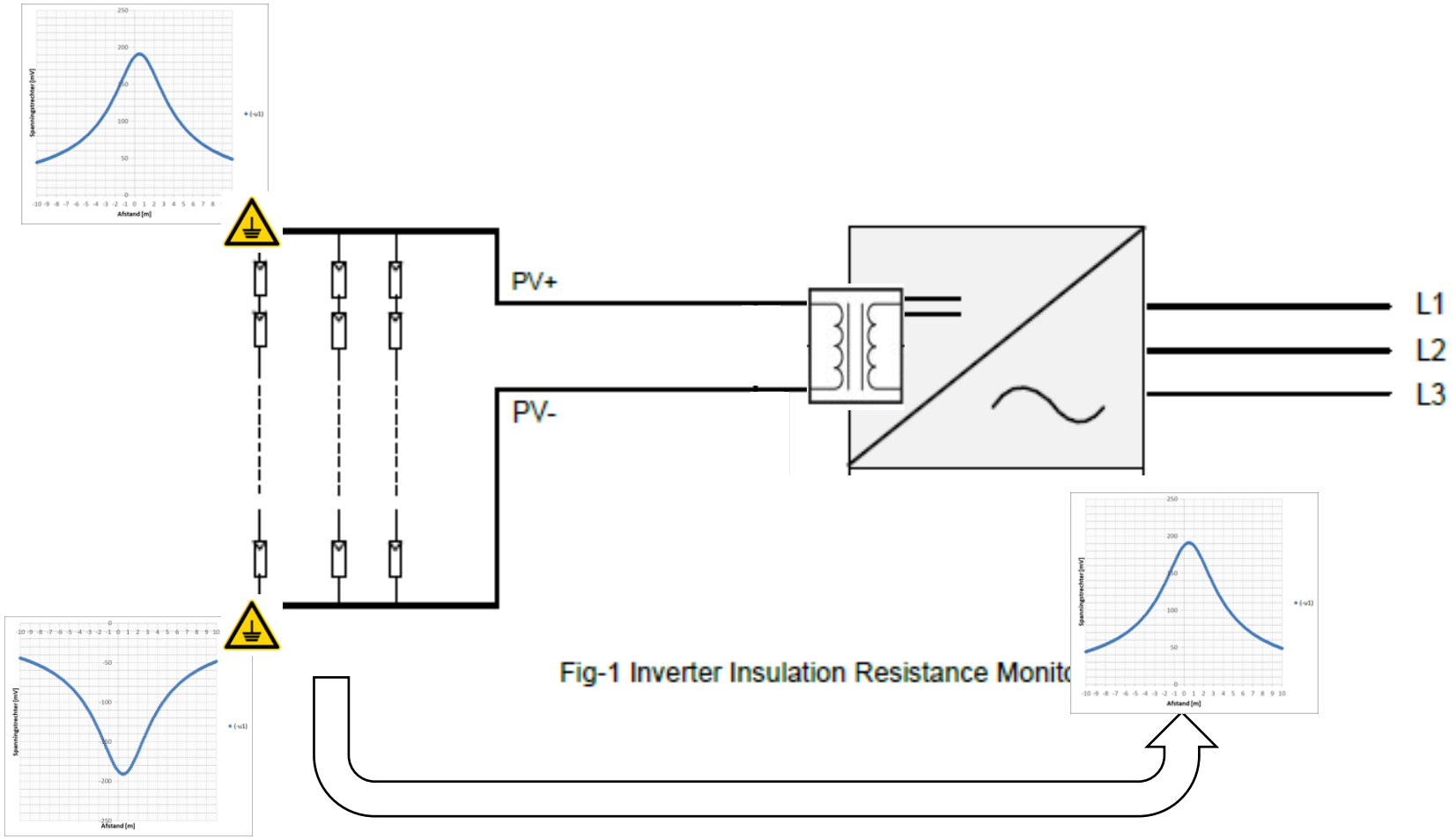
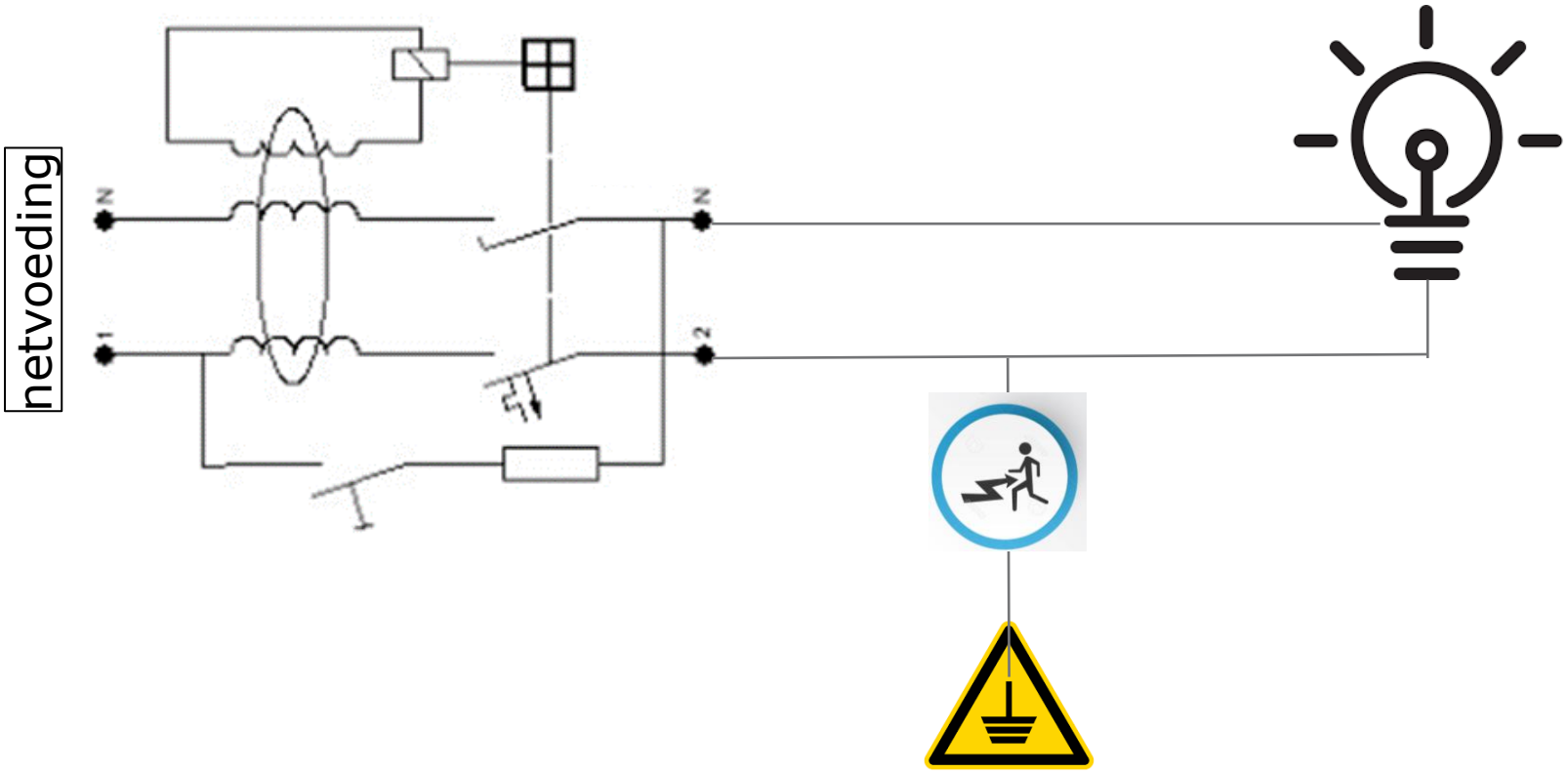


Fig-1 Inverter Insulation Resistance Monito

Aardlekschakelaar (RCD/RCMU)



RCD lekstromen

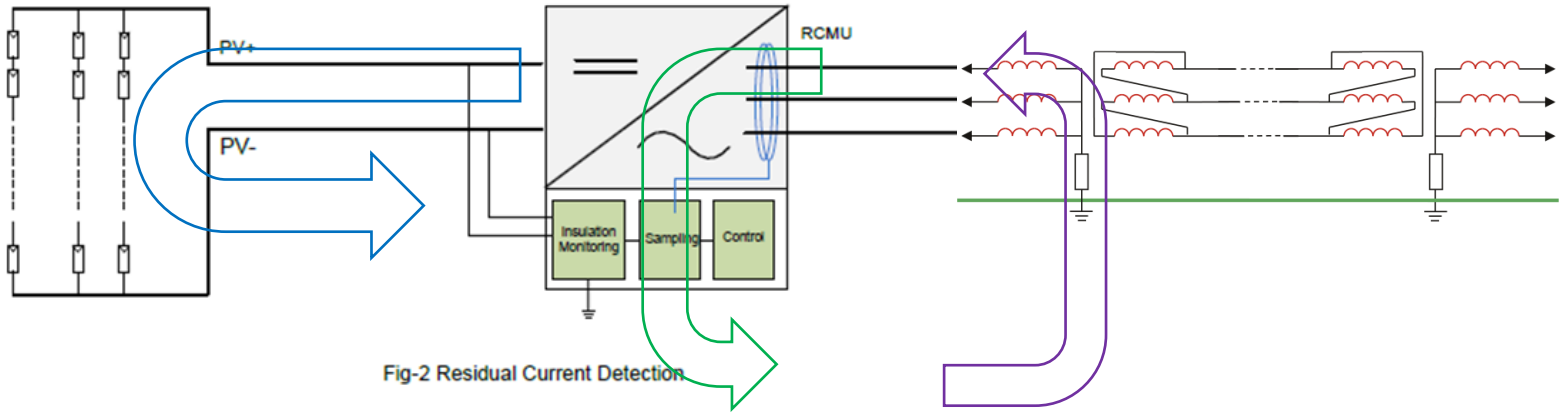
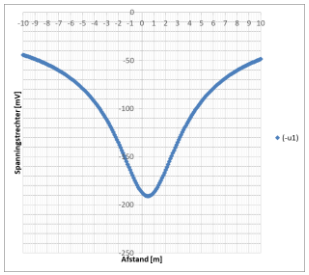
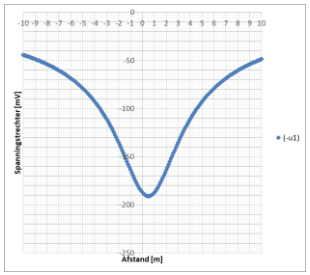
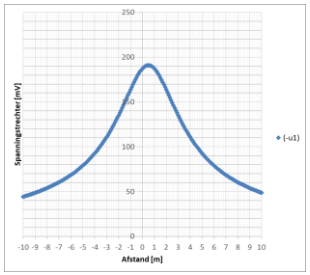


Fig-2 Residual Current Detection







NEN-EN-IEC 62109-2

Table 30 – Requirements based on inverter isolation and array grounding [1)]

Array grounding:	Ungrounded[a] or functionally grounded	Ungrounded or functionally grounded	Grounded
Inverter isolation:	**Non-isolated**	**Isolated**	**Isolated**
Minimum inverter isolation requirements	Not applicable	Basic or reinforced [b] insulation and Leakage current type testing per 4.8.3.2 (shock hazard) and 4.8.3.3 (fire hazard) to determine the requirements for array ground insulation resistance and array residual current detection, below	
Array ground insulation resistance measurement	Before starting operation, per 4.8.2.1 or 4.8.2.2 Action on fault: indicate a fault in accordance with 13.9, and do not connect to the mains	Before starting operation, per 4.8.2.1 or 4.8.2.2 Action on fault: For inverters with isolation complying with the leakage current limits for both shock and fire hazards under "Minimum inverter isolation requirements" above, indicate a fault in accordance with 13.9 For inverters with isolation not complying with the above minimum leakage current values, indicate a fault in accordance with 13.9, and do not connect to the mains	Not required [d]
Array residual current detection	Either a) 30 mA RCD[c] between the inverter and the mains per 4.8.3.4, or b) monitoring for both continuous excessive residual current per 4.8.3.5.1 a) and excessive sudden changes per 4.8.3.5.1 b) Action on fault: shut down the inverter, disconnect from the mains, and indicate a fault in accordance with 13.9	Not applicable for inverters with isolation complying with the leakage current limits for both shock and fire hazards under "Minimum inverter isolation requirements" above. Inverters with isolation not complying with the leakage current limits for shock hazard per 4.8.3.2 require monitoring for sudden changes in residual current per 4.8.3.5.1 b) or use of an RCD per 4.8.3.4 Inverters with isolation not complying with the leakage current limits for fire hazard per 4.8.3.3 require monitoring for excessive continuous residual current per 4.8.3.5.1 a) or use of an RCD per 4.8.3.4 Action on fault: shut down the inverter, disconnect from the mains, and indicate a fault in accordance with 13.9.	





R-ISO

4.8.2.1 Array insulation resistance detection for inverters for ungrounded arrays

Inverters for use with ungrounded arrays shall have means to measure the DC insulation resistance from the PV input (array) to ground before starting operation, or shall be provided with installation instructions in accordance with 5.3.2.11.

If the insulation resistance is less than $R = (V_{MAX\ PV}/30\ mA)$ ohms, the inverter:

- for isolated inverters, shall indicate a fault in accordance with 13.9 (operation is allowed); the fault indication shall be maintained until the array insulation resistance has recovered to a value higher than the limit above;
- for non-isolated inverters, or inverters with isolation not complying with the leakage current limits in the minimum inverter isolation requirements in Table 30, shall indicate a fault in accordance with 13.9, and shall not connect to the mains; the inverter may continue to make the measurement, may stop indicating a fault and may connect to the mains if the array insulation resistance has recovered to a value higher than the limit above.

The measurement circuit shall be capable of detecting insulation resistance below the limit above, under normal conditions and with a ground fault in the PV array.

Compliance is checked by analysis of the design and by testing, as follows:

Compliance with the values of current shall be determined using an RMS meter that responds to both the AC and DC components of the current, with a bandwidth of at least 2 kHz.

The inverter shall be connected to PV and AC sources as specified in the reference test conditions in Part 1, except with the PV voltage set below the minimum operating voltage required for the inverter to attempt to start operating. A resistance 10 % less than the limit above shall be connected between ground and each PV input terminal of the inverter, in turn, and then the PV input voltage shall be raised to a value high enough that the inverter attempts to begin operation. The inverter shall indicate a fault in accordance with 13.9 and take the action (operating or not operating as applicable) required above.

It is not required to test all PV input terminals if analysis of the design indicates that one or more terminals can be expected to have the same result, for example where multiple PV string inputs are in parallel.

NOTE The resistance to ground of the DC supply or simulated array used to power the inverter during this test, must be taken into account unless it is large enough not to significantly influence the test result.

4.8.2.2 Array insulation resistance detection for inverters for functionally grounded arrays

Inverters that functionally ground the array through an intentional resistance integral to the inverter, shall meet the requirements in a) and c), or b) and c) below:

NOTE System designers using resistance between the array and ground that is not integral to the inverter, must consider whether a shock hazard on the array is created or made worse by the addition of the resistance, based on the array design, resistance value, protection against direct contact with the array, etc. Requirements for such considerations are not included here because if the inverter does not provide the resistance, it is neither the cause of, nor capable of protecting against, the hazard.

a) The value of the total resistance, including the intentional resistance for array functional grounding, the expected insulation resistance of the array to ground, and the resistance of any other networks connected to ground (for example measurement networks) must not be lower than $R = (V_{MAX\ PV}/30\ mA)$ ohms. The expected insulation resistance of the array to ground shall be calculated based on an array insulation resistance of 40 MΩ per m^2, with the surface area of the panels either known, or calculated based on the inverter power rating and the efficiency of the worst-case panels that the inverter is designed to be used with.

NOTE Designers should consider adding design margin, based on considerations such as panel aging which will reduce the array insulation resistance over time and any AC component of the leakage current caused by array capacitance to ground. The array insulation resistance measurement in c) below will ensure that total resistance is not too low and the system remains safe, but if the design margin is not adequate, the system will refuse to connect following the array insulation resistance check.

The installation instructions shall include the information required in 5.3.2.12.

b) As an alternative to a), or if a resistor value lower than in a) is used, the inverter shall incorporate means to detect, during operation, if the total current through the resistor and any networks (for example measurement networks) in parallel with it, exceeds the residual current values and times in Table 31 and shall either disconnect the resistor or limit the current by other means. If the inverter is a non-isolated inverter, or has isolation not complying with the leakage current limits in the minimum inverter isolation requirements in Table 30, it shall also disconnect from the mains.

The inverter may attempt to resume normal operation if the array insulation resistance has recovered to a value higher than the limit in 4.8.2.1.

NOTE For the inverter to make the measurement of array insulation resistance and meet the limit in 4.8.2.1, the array functional grounding resistor will need to remain disconnected (or the current limiting means will have to remain in effect) until after the array insulation resistance measurement has been made.

Compliance with a) or b) is checked by analysis of the design and for case b) above, by the test for detection of sudden changes in residual current in 4.8.3.5.3.

c) The inverter shall have means to measure the DC insulation resistance from the PV input to ground before starting operation, in accordance with 4.8.2.1.

RCD

IEC 62548
- maximum 300 mA for PCEs with continuous output power rating ≤ 30 kVA;
- the lesser of 5 A or (10 mA per kVA) of rated continuous output power for PCEs with continuous output power rating > 30 kVA.

4.8.3.5 Protection by residual current monitoring

4.8.3.5.1 General

Where required by Table 30, the inverter shall provide residual current monitoring that functions whenever the inverter is connected to the mains with the automatic disconnection means closed. The residual current monitoring means shall measure the total (both a.c. and d.c. components) RMS current.

As indicated in Table 30 for different inverter types, array types, and inverter isolation levels, detection may be required for excessive continuous residual current, excessive sudden changes in residual current, or both, according to the following limits:

a) Continuous residual current: The inverter shall disconnect within 0,3 s and indicate a fault in accordance with 13.9 if the continuous residual current exceeds:
   - maximum 300 mA for inverters with continuous output power rating ≤ 30 kVA;
   - maximum 10 mA per kVA of rated continuous output power for inverters with continuous output power rating > 30 kVA.

The inverter may attempt to re-connect if the array insulation resistance meets the limit in 4.8.2.

b) Sudden changes in residual current: The inverter shall disconnect from the mains within the time specified in Table 31 and indicate a fault in accordance with 13.9, if a sudden increase in the RMS residual current is detected exceeding the value in the table.

Table 31 – Response time limits for sudden changes in residual current

Residual current sudden change	Max time to inverter disconnection from the mains
30 mA	0,3 s
60 mA	0,15 s
150 mA	0,04 s

NOTE These values of residual current and time are based on the RCD standard IEC 61008-1.

Exceptions:

- monitoring for the continuous condition in a) is not required for an inverter with isolation complying with 4.8.3.3;
- monitoring for the sudden changes in b) is not required for an inverter with isolation complying with 4.8.3.2.

De uitzondering op “sudden changes”:

4.8.3.6 Systems located in closed electrical operating areas

For systems in which the inverter and a DVC-B or DVC-C PV array are located in closed electrical operating areas, the protection against shock hazard on the PV array in subclauses 4.8.2.1, 4.8.2.2, 4.8.3.2, 4.8.3.4, and 4.8.3.5.1 b) is not required if the installation information provided with the inverter indicates the restriction for use in a closed electrical operating area, and indicates what forms of shock hazard protection are and are not provided integral to the inverter, in accordance with 5.3.2.7. The inverter shall be marked as in 5.2.2.6.

IEC 62548 Insulation Monitoring Device

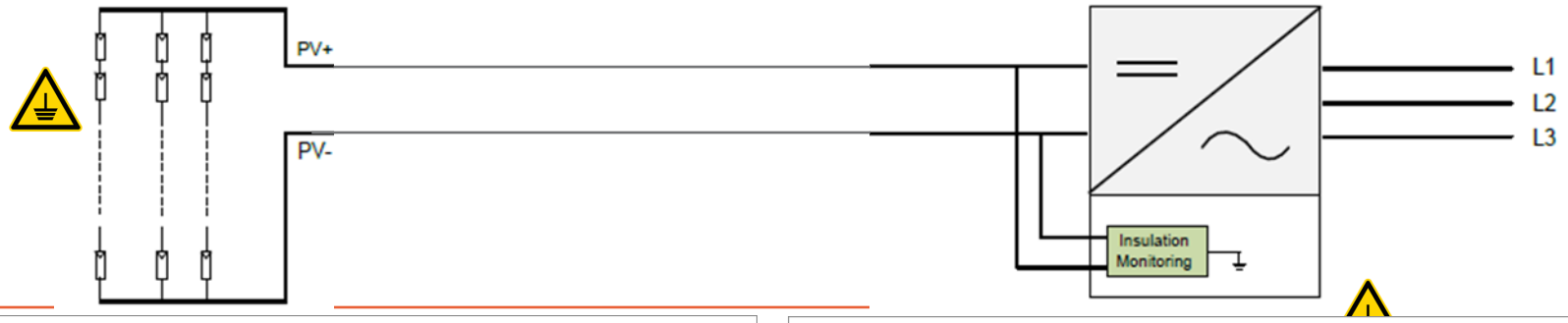
Minimum threshold values for detection shall be according to Table 2.

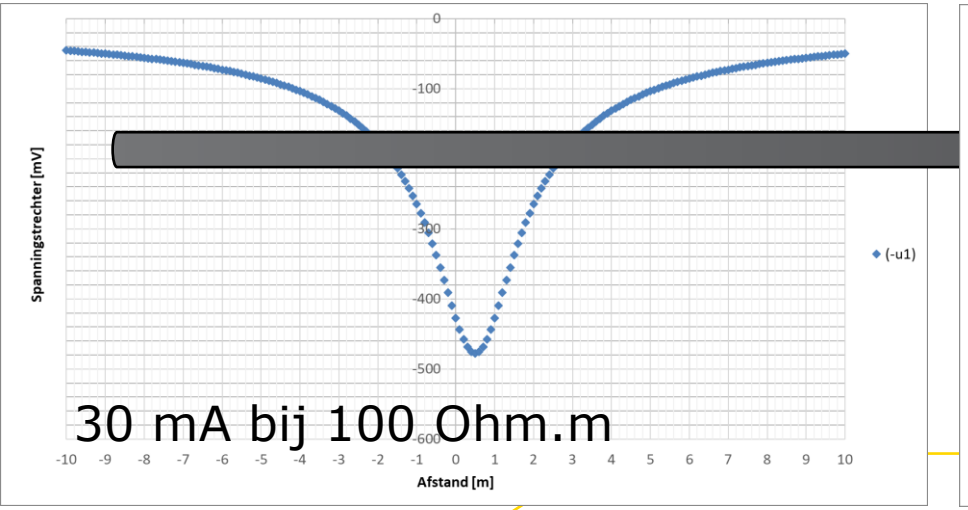
Table 2 – Minimum insulation resistance thresholds for detection of failure of insulation to earth

PV array rating kW	R limit kΩ
≤ 20	30
> 20 and ≤ 30	20
> 30 and ≤ 50	15
> 50 and ≤ 100	10
> 100 and ≤ 200	7
> 200 and ≤ 400	4
> 400 and ≤ 500	2
> 500	1

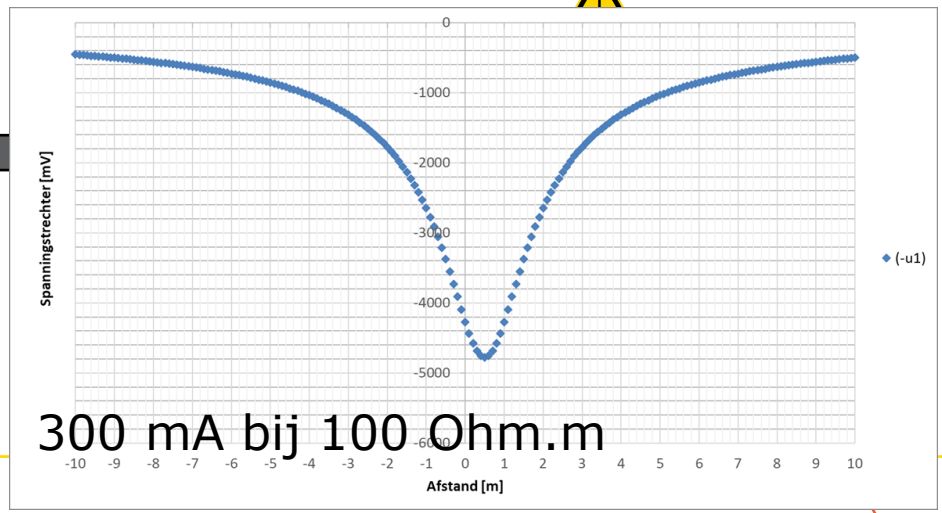
The functionality for insulation resistance monitoring or measurement may be provided within the PCE according to IEC 62109-2.

Voorbeeld: grondgebonden particulier systeem





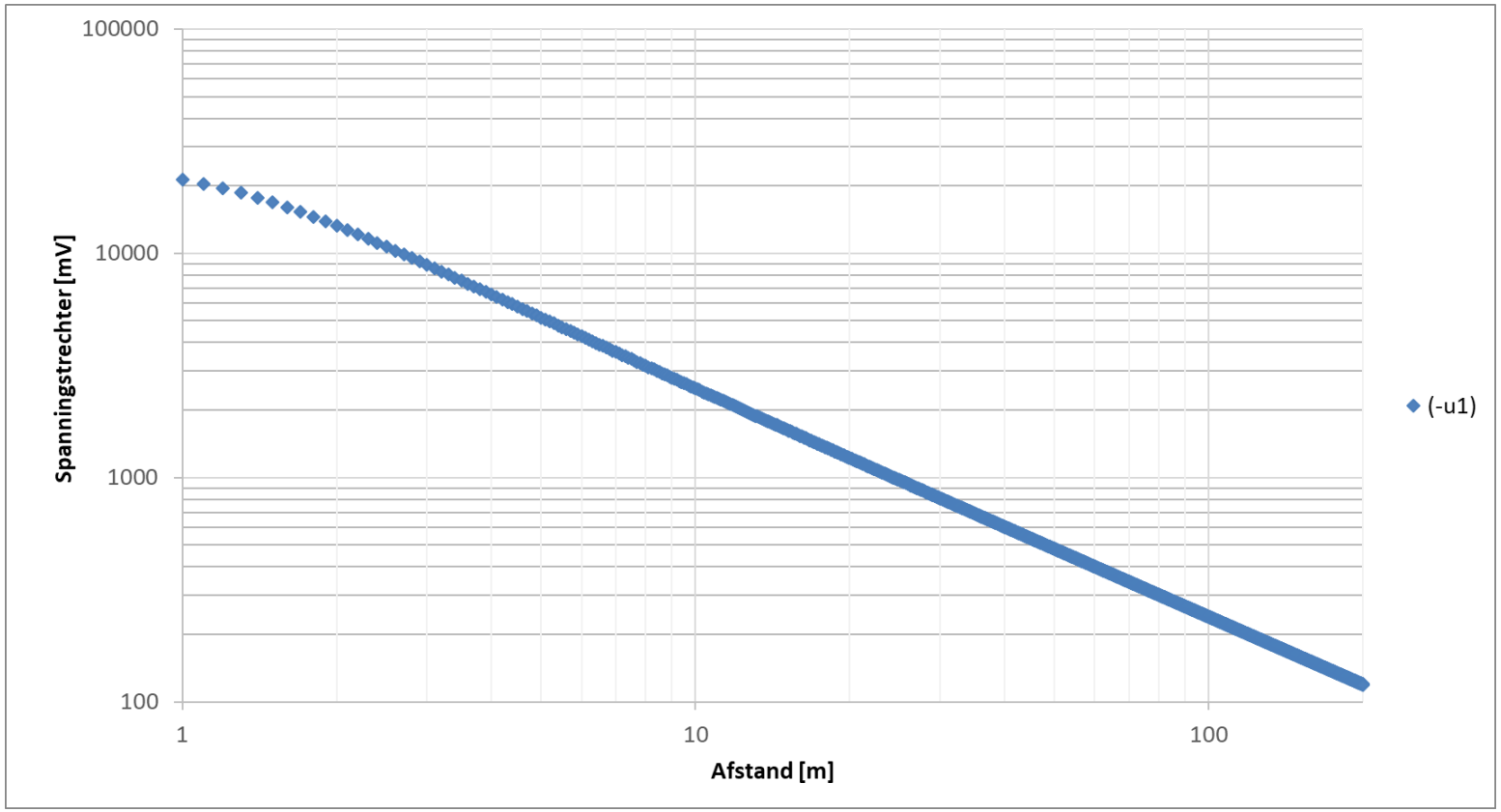
30 mA bij 100 Ohm.m



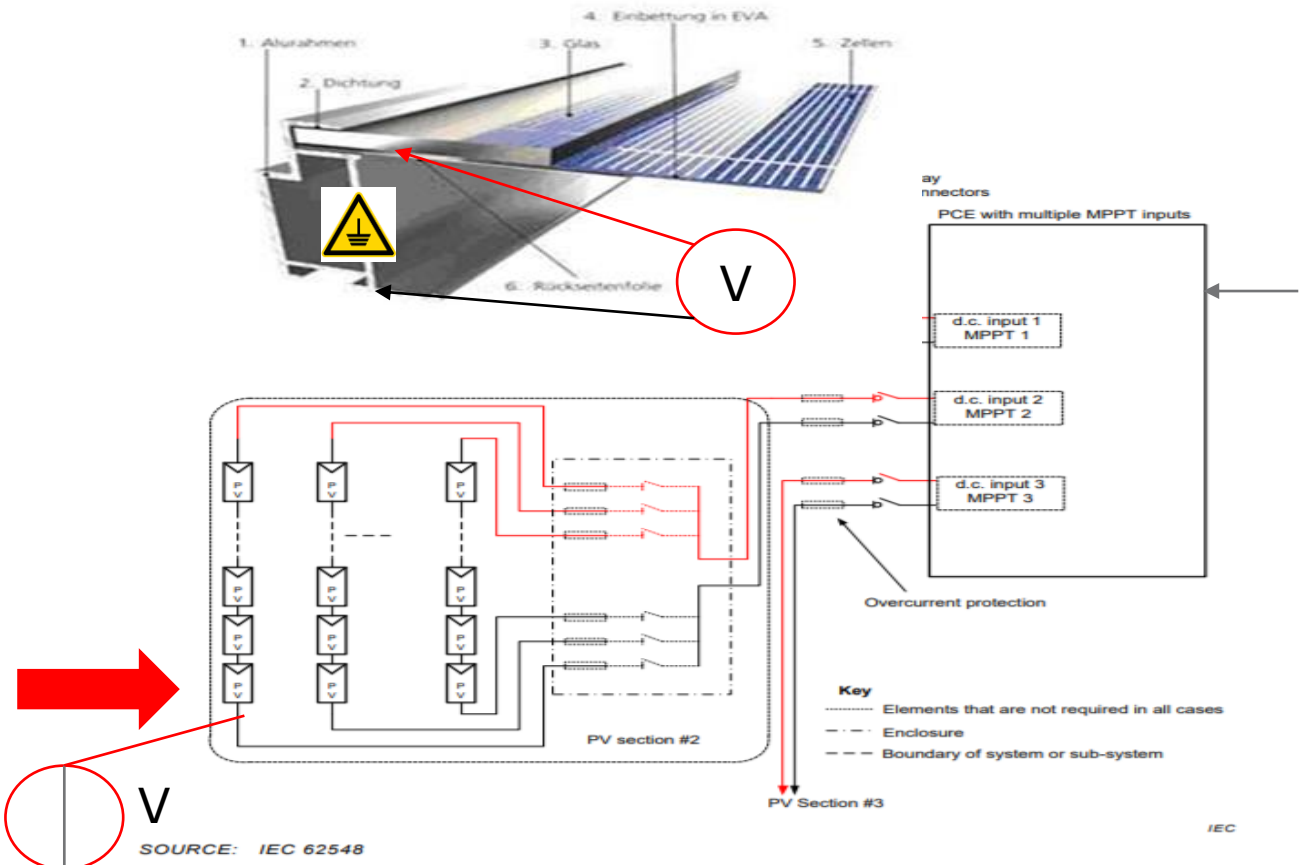
300 mA bij 100 Ohm.m

1500 mA bij 100 Ohm.meter

(150 kW inverter IEC 62109-2; > 500 kW array IEC 62548)



PID

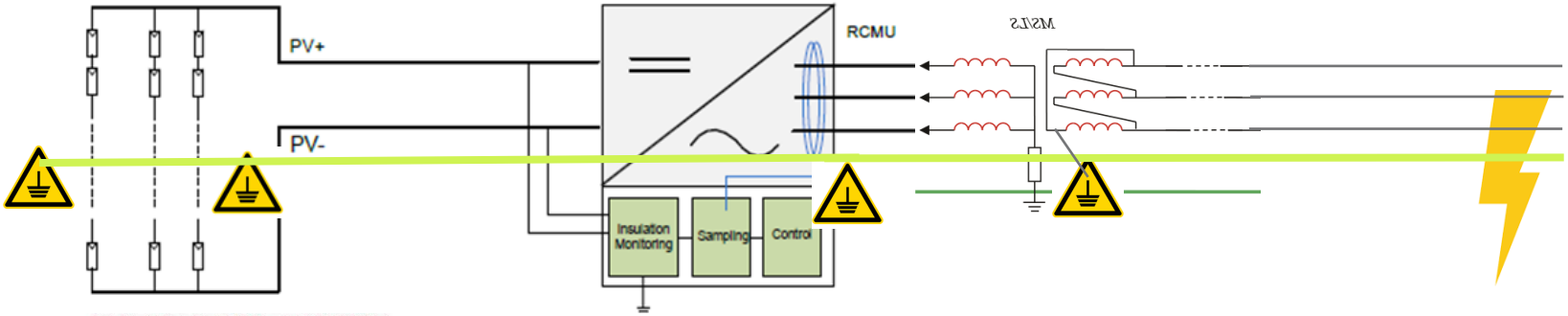


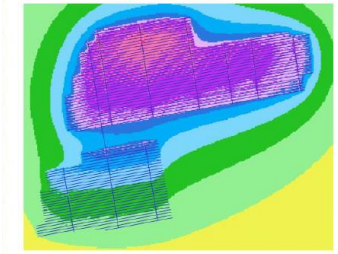
SOURCE: IEC 62548

Figure 2 – PV array example using a PCE with multiple MPPT d.c. inputs

AC: NEN 3654

Doorverbinden aardingen zorgt bij sluiting naar aarde (1-fase sluiting) voor spanningspiek op park.





Doorverbinden aardingen zorgt bij sluiting naar aarde (1-fase sluiting) voor spanningspiek op park.
Beoordeling weerstandsbeïnvloeding is nodig.

agenda

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NEN-EN 50162

Table 1 – Acceptable positive potential shifts ΔU for buried or immersed metal structures which are not cathodically protected

Structure metal	Resistivity of the electrolyte ρ (Ωm)	Maximum positive potential shift ΔU (mV) (including IR-drop)	Maximum positive potential shift ΔU (mV) (excluding IR-drop)
Steel, cast iron	≥ 200	300	20
	15 to 200	1,5 x ρ*	20
	< 15	20	20
Lead		1 x ρ*	
Steel in buried concrete structures		200	
*ρ in Ωm			

" 1,5 * Rho" Komt overeen met ongeveer Afstand = 100 * I [m]

Criteria

- Velin voorwaarden: Geen beïnvloeding, zie NEN-EN-ISO 12954 /NEN-EN-ISO-15589-1. Deze normen verwijzen naar NEN-EN 50162

Alleen achteraf vast te stellen

6.1.2 Structures with cathodic protection

Structures protected against corrosion by cathodic protection shall be deemed to be exposed to unacceptable stray current interference if the IR free potential is outside the protective potential range (see EN 12954).

To evaluate the acceptability of stray current interference the installati… …ons should be considered.

In situations with fluctuat… …ms as described in Annex D can also be used t…

…g. under d.c. traction influence) there are reasons to doubt the accuracy of …ment method used other measurement techniques (e.g. weight loss coupons) can be used to establish that the structure is cathodically protected.

Measurements should be carried out during a period of normal operation of the interfering system.

Daarom 200 mV als maximale BBP beïnvloeding
Uitgaande van maximale lekstroom van 1 omvormer

Alleen vast te stellen bij geen/nauwelijks beïnvloeding

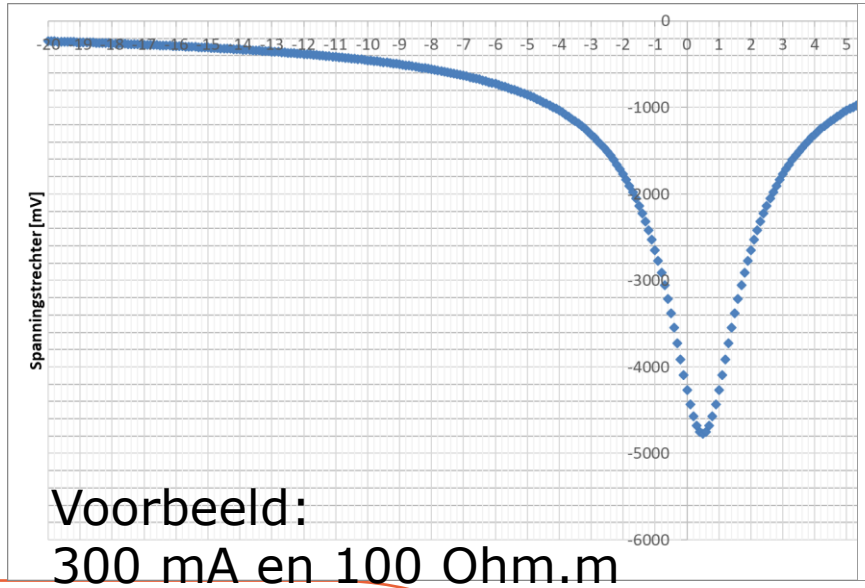
200mV beïnvloedingsafstand

Enkele puntbron zonder achterliggend aardingssyteem

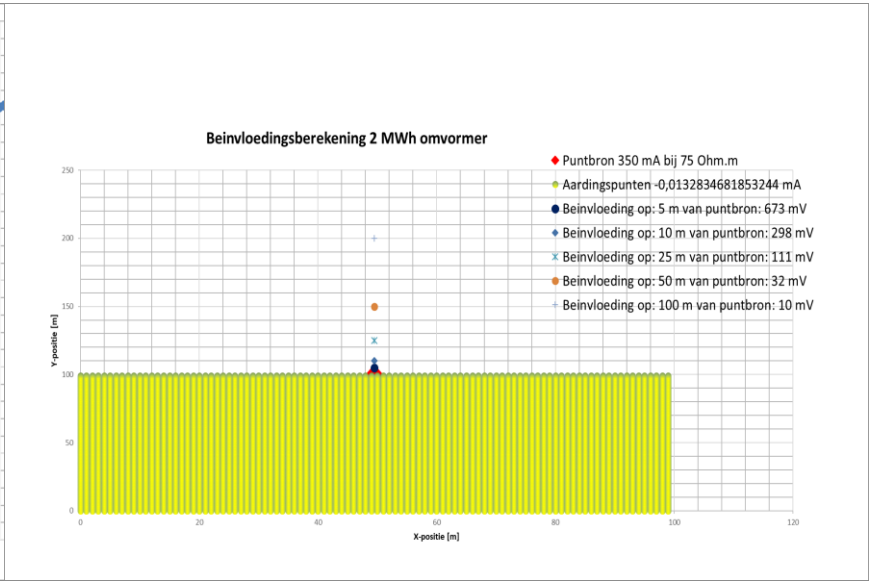
D=0,8*ρ[Ωm]*I[A]

Enkelvoudige puntbron met achterliggend aardingssysteem

D=5+0,2*ρ[Ωm]*I[A]



Voorbeeld:
300 mA en 100 Ohm.m



agenda

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- Hoe verder

Maatregelen

- Bewustwording
  - "Vragenlijst" door parkontwikkelaar in te vullen
- Voorkomen
  - Afstand houden
  - Stromen beperken
    - R-ISO
    - RCD
    - In beïnvloede zone: Geen aardingen / aardkabels isoleren, ondergrondse DC kabels in mantelbuizen

  Borgen
    - Afspraken maken m.b.t. handhaving van de ingestelde waarden

  Controle

  I. Jaarlijks 24 uur meten (dus meetpalen plaatsen)
  II. Remote monitoring: IOT in ontwikkeling

agenda

- Historie
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Hoe verder

- Wat is nog niet 100% duidelijk/uitgezocht:
  - RCD, per array of per omvormer (verschil in normen/benamingen) effect RCD lekstromen op de aardpotentiaal van het park
  - Effect van beïnvloeding bij doorkruisen van een park (verdubbeling beïnvloeding ingeval van opgetilde aarding)
  - Effect van Anti PID systemen (“Anti PID”, “PID recovery)
  - Waarom zit er verschil in parkbenadering, centrale omvormers/string omvormers. (mss NEN 1010?)
  - Waarom geen gearmeerde DC kabels en wel gearmeerde AC kabels
  - Wat is de beïnvloeding vanuit niet grondgebonden parken (boeren schuren)

- Velin bijlage: niet voor lagedrukleidingen of constructies
- Vervolgoverleg leidingeigenaren-adviesbureaus voortzetten.
- NPR? geen verplichting, moet binnen 3 jaar naar norm omgezet worden. Onder NEN 3650? Of in NPR 9090 of NPR 5310?

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Aanvullende vragen?