FAQ ON EARTHING STANDARDS 16/08/2018

This document has been updated to include changes made to substation earthing layouts that have been made necessary due to copper theft. The main changes to be aware of are the grading ring will be changed to $70mm^2$ bare copper coated steel conductor buried at a depth of 150mm below finished ground line. The grading ring will no longer be connected to the HV earth electrodes. Separate connections to the HV earth electrodes will be $70mm^2$ PVC insulated copper conductor buried at a depth of 1200mm. Earthing connection single line diagrams for the different substation configurations are shown at the end of this document.

Note that for the Modular Packaged Substation (MPS) only, 2 additional electrodes are connected to the grading ring. These grading ring electrodes are to equalize touch potentials. They consist of a single 1.5m long earth stake and do not have a target earth resistance.

Western Power will continue to specify prescribed values of earthing resistances in the short term but will be moving to risk based earthing in accordance with AS/NZS 7000:2016 and AS 2067:2016 in the near future.

FAQs

1) What minimum readings do we have to get for:

a) **Standalone RMU** – maximum 10 ohms per HV electrode where 2 HV electrodes exist per RMU.

b) **Standalone TX (up to 1,000kVA)** – refer to table below for resistance per HV electrode. When HV and LV earths are combined then final installation shall be no greater than 1ohm.

Pole top transformer not greater than 315 KVA	max 30 Ω
Pad-mount transformer rating up to 160 KVA	max 30 Ω
Pad-mount transformer rating 160 KVA and over	max 10 Ω

c) **Combined TX/RMU** – maximum 10 ohms per HV electrode where 2 HV electrodes exist per TX/RMU site. When HV and LV earths are combined the final installation shall be no greater than 1 ohm.

2) Do we drill additional rods at Pillars (UG network) or LV poles (OH network) to get to the minimum combined earth reading of <1ohm?

Yes, this can be done if <1ohm combined earthing cannot be met. This does not eliminate the requirement of achieving the required earth resistances at each HV electrode of a TX or RMU site. It may be necessary to drill at pillars or LV poles where the LV network (of new subdivision) is sparse i.e. less than 20 pillars. Refer also to Q6.

Where additional rods are drilled at a pillar to achieve <1ohm combined earthing, the pillar shall be marked "DEEP EARTH". The label will be fitted inside the pillar, be non conductive and be indelible. The deep earth will then form an integral part of the new installation and relocation of that pillar needs to account for the deep earth. The Deep Earth shall be marked on the 'As Constructed' drawing. A deep earth depth is typically 30m.

3) Can we install counterpoise earthing, i.e. install an earth cable (bare or insulated) between the transformer site and another HV electrode further away from the site?

No. The reason for this is earth potential rise can transfer voltages into adjacent equipment and/or services. Our preference is to use the cable screens (neutrals) that are insulated and connect them to deep earths at pillars.

4) Where does the minimum 10ohms per HV electrode for ground mounted equipment come from?

a) The 10ohm is a standard industry resistance that is required to allow protection to operate correctly.
b) It has also been specified to ensure adequate surge protection operation
c) Each HV electrode needs to be 10 ohm such that if the connection from 1 HV electrode is broken (eg. for testing) or has been damaged the TX/RMU is still connected via the other 10ohm HV earth electrode, i.e. redundancy required as per AS/NZS 3000:2007, Section K.11.2.
d) It is the level required (AS/NZS 3000:2007, Section K.11.5.2) for LV earthing for TX >500kVA when LV earths are separated from HV earths. Reasons are similar to (a).

EQUIPMENT ITEM	**CMEN Areas**		**Separately Earthed Areas**		
	Local Earth Requirements	**Area CMEN**	**HV Earth Requirement**	**LV Earth Requirement**	**Area MEN**
Standard Pole-Mounted Distribution Transformer	Connect all items to 1 x **30Ω max** local HV earth and area CMEN.	**1Ω max**	Separate Earth system not usually employed. Requires approval from Earthing Engineer prior to use.	Separate Earth system not usually employed. Requires approval from Earthing Engineer prior to use.	**N/A**
Ground Mounted URD Substation	Connect all items to 2 x **10Ω max** local HV earths and area CMEN.	**1Ω max**	Separate Earth system not usually employed. Requires approval from Earthing Engineer prior to use.	Separate Earth system not usually employed. Requires approval from Earthing Engineer prior to use.	**N/A**
HV Switch Poles Country	Connect all items to 1 x **30Ω max** local HV earth and running earth.	**N/A**	Connect all items to **30Ω max** local earth and running earth	N/A	**N/A**

- Less than 10 ohms (ground mount) or 30 ohms (pole mount) on each HV earth electrode (rod)
- Less than 10 ohms combined on a stand alone RMU site
- Less than 1 ohm combined including neutrals on a TX site
- Less than 1 ohm combined including neutrals on a RMU & TX site.

5) How many connections are required from the terminal bar and the HV earth electrodes?

Refer to the connection single line diagrams at the end of this document. The *Terminal Bar* (defined in AS/NZS 3000:2007, Section K.11.4.4) of the transformer consists of 2 parts that are interconnected i.e. LV bar and HV bar. The reason for having an interconnection (Combined HV & LV link is factory fitted earth cable) is to allow for separate HV and LV earthing if deemed absolutely necessary. With a single *Terminal Bar* this would not be possible.

There are 2 connections to the HV earth electrodes. Note that these no longer are connected to the grading ring but are separate connections between the HV earth bar and the HV electrode. Note also that for the Modular Packaged Substations (MPS) only there are two single 1.5m length earth electrodes connected to the grading ring for the purpose of equalizing touch potentials.

6) What are the steps and process to achieve earthing for a TX that complies with the standards?

There are two options for achieving electrode and system earthing resistance requirements. One option is to install the earth equipment on site until the requirements are achieved. The process for this is given in the table below. The other option is to engage an Earthing Consultant before the subdivision is installed to undertake an earthing design to determine the extent of earthing works required for the site that satisfies safe touch, step and transfer potential criteria. For both cases field measurements must be made to prove the network impedances.

Step	Description	Responsibility
1	Install (hammer or drill) HV earth rods at diagonal corners of ground mounted TX site or at the pole base for pole mounted TX. Each HV electrode must have a maximum resistance of 10 ohms for ground mounted TX and 30 ohms for pole mounted TX. (Note that grading ring electrodes consist of a single 1.5m long earth stake and do not have a target earth resistance). Connect up all earths on new network. This includes transformer HV and LV earths and pillar earths and check combined earthing resistance. The aim of the test is to achieve 1 ohm or less resistance. **Has <1ohm combined earthing been achieved?** **Yes – finished.** **No – go to next step**	Developer/ installer
2	**Drill deep earth** a) At pillar furthest from the TX site for underground network. b) At pole at end of the LV circuit for overhead network c) Check combined earth resistance does not exceed 1 ohm. If exceeded proceed to step 3 Note: Drilling an earth at the furthest pillar or LV pole is to ensure the earth is not within the zone of influence of the TX earth. Earths can be installed within the zone of influence however they will not be as effective in reducing the overall earth mat resistance. **Has <1ohm combined earthing been achieved?** **Yes – finished.** **No – go to next step** .	Developer/ installer
3	**Combined earth exceeded for single remote drilled earth** a) Drill at least 3 remote (2 additional) pillars or LV poles from the transformer and each other to try to achieve the 1 ohms combined earthing resistance b) Where the 1 ohm combined earthing resistance is not achievable the maximum combined earth resistance permitted is 3 ohms before going to step 4 **Has <3 ohm combined earthing been achieved?** **Yes – finished.**	Developer/ installer

	No – go to next step	
4	Interconnect the new subdivision LV neutrals with the existing adjacent network LV neutrals. **Has <1ohm combined earthing been achieved?** **Yes – finished.** **No – go to next step.**	Developer/ installer
5	Suitably qualified engineer to conduct touch, step and transfer potential calculations to determine acceptability of installation. Note, separate earthing will only be considered when all the above has not achieved the desired EPR.	Developer /Earthing Consultant
6.	Conform calculations	Western Power
7.	Copy of results and calculations must be forwarded to WP.	Developer /Earthing Consultant

7) What details do I need to submit to the Earthing Engineer, if at step 5?

Details to include:

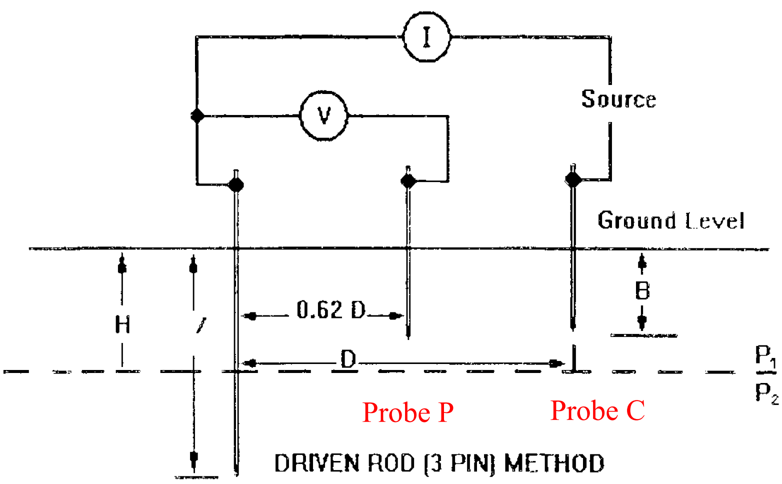
a) Design Drawing of the site
b) Location, depth and earth resistance of HV electrodes installed (individually)
c) Combined earth reading with HV and LV connected (i.e. HV electrodes, grading ring, HV and LV earth link all connected)
d) Length of test leads used to measure the earth readings (i.e. length to P and C probe from the HV earth electrode)
e) Indication of the first HV protection device upstream from the site. If TX only site, then the upstream fuse location and details. If RMU or RMU/TX site, then the first upstream recloser or feeder circuit breaker.

8) What length of earth test lead should be used to measure the electrode resistance?

Most testers adopt the Fall-of-Potential method using a Current probe (C) and a Potential probe (P) that is placed 62% the distance of probe C from the earth electrode under test.

When earth testing with Megger, if depth of the electrode is *l*, then the test probe P of the earth tester must be placed at minimum (or further) 2x*l* from the earth electrode and the C probe must be 3.2x*l* from the earth electrode (in that ratio where P probe is 62% the distance between the earth electrode and C probe). This ensures an accurate earth resistance measurement, otherwise the measurement will result in higher resistance readings due to summation of the zones of influence of the earth electrode and the C probe. Refer to arrangement below.

EXAMPLE - if rods have been drilled to 10m (*l*) then probe P must be at a minimum (or more) 20m (2 x *l*) from earth electrode and probe C must be 32m (3.2 x *l*) from earth electrode.



DRIVEN ROD (3 PIN) METHOD

Below is a guide of test lead lengths required to test electrodes of various depths, which should be followed to achieve correct earth resistance readings. The test lead length is not limited to 320m, where the test equipment is capable of longer lengths.

ELECTRODE DEPTH	Test Lead lengths from Earth Electrode	
	Potential Probe (P)	Current Probe (C)
<15m	30m	50m
15 - 30m	60m	100m
30 - 45m	90m	150m
45 - 60m	120m	190m
60 - 75m	150m	240m
75 - 100m	200m	320m

9) Are the earthing standards changing and how will this impact construction?

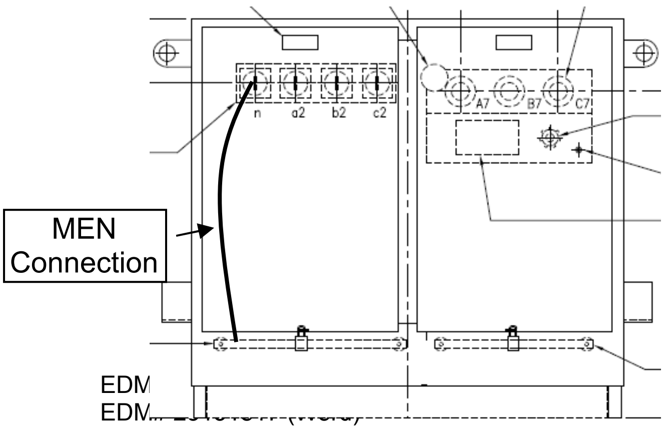
Adherence to AS3000:2007 has been retained at present but will be superseded by AS2067:2016 in the near future. AS2067:2016 does not define resistance values to be achieved but instead defines touch voltage limits that are applied to a risk assessment. This means earthing systems need to be designed to meet the specific risk criteria for a particular site and depends on:

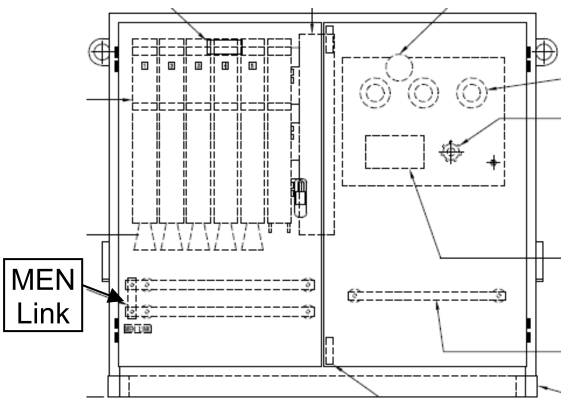
a) Earth fault current and duration
b) Soil resistivity
c) Level of LV interconnection
d) Other factors…

It is envisaged that each design drawing will have on it a resistance value that needs to be achieved and any other remedial earthing work required to ensure touch voltage limits are satisfied, all of which are derived by undertaking a level of earthing design. Standard resistance values of 30ohm, 10ohm and 1ohm may not exist.

10) Do transformers need to have MEN connection if one is provided in the LV switchboard?

Yes, the transformer LV side must have a connection from LV neutral (either from neutral bushing or neutral bar) to the LV earth bar on the transformer. Similarly, an MEN is required in the Western Power LV distribution board which feeds the street or customers. The customer also needs to install an MEN at their installation in accordance with AS/NZ3000:2007. An MEN is required in the transformer because a separate earth cable is not connected between transformer earth bar and LV distribution board earth bar.



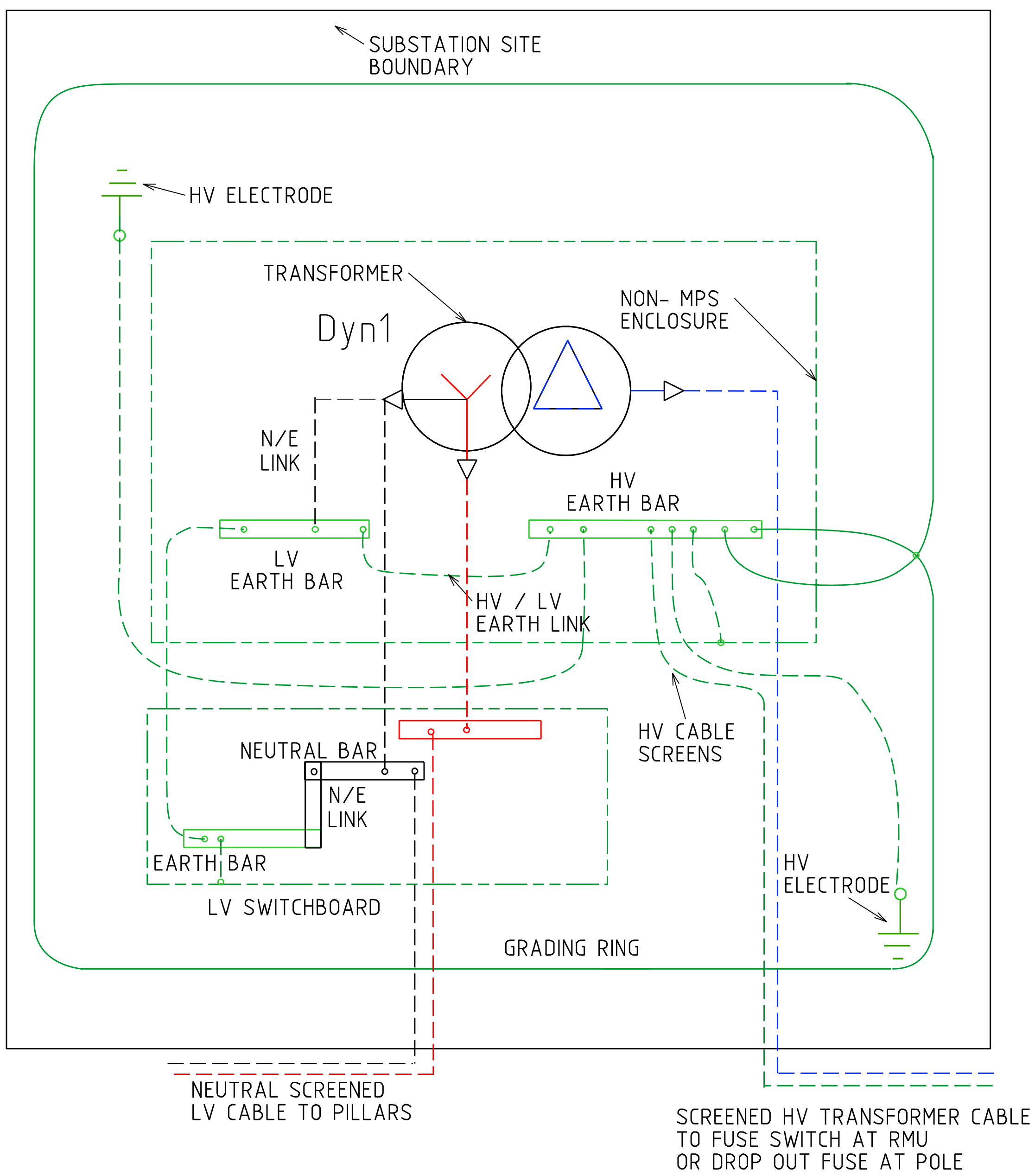


Ground-mount Substation Earthing Connection Single Line Diagrams

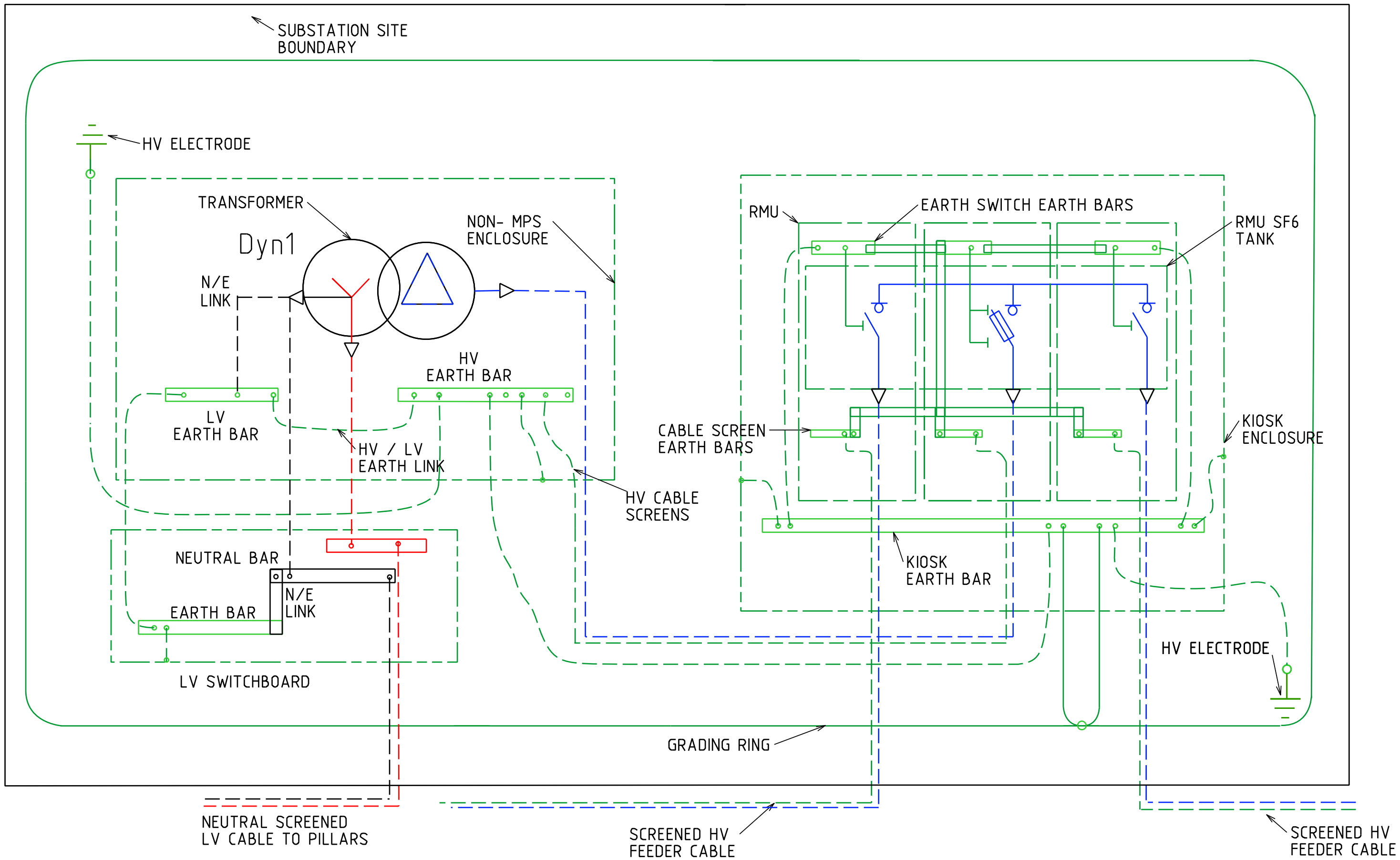
Drawing Notes:

1. HV electrode connections are $70mm^2$ PVC insulated copper conductor buried 1200mm below finished ground level.
2. Grading ring connections are $70mm^2$ copper coated steel conductor buried 150mm below finished ground level.

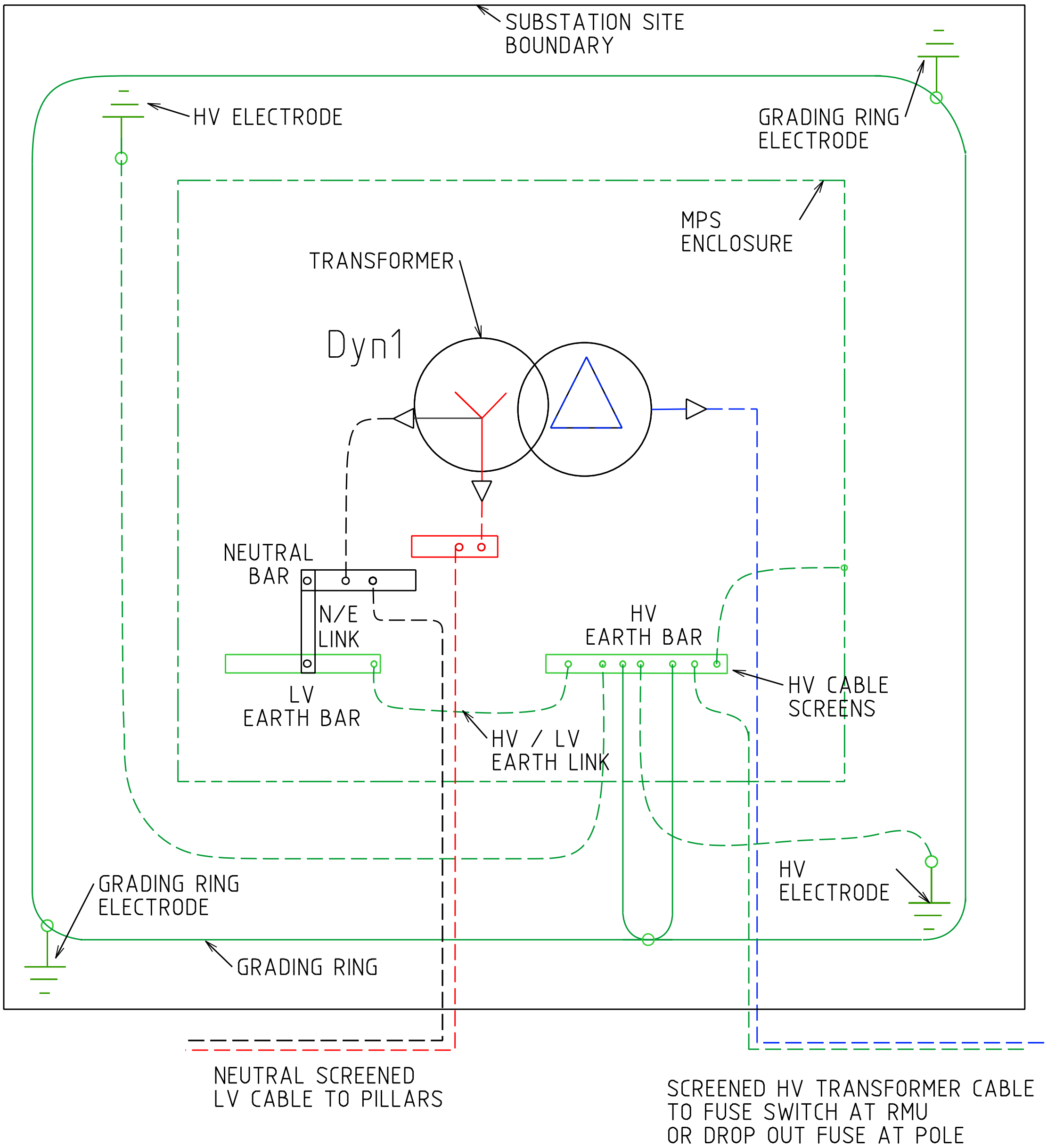
DISTRICT NON-MPS WITH LV SWITCHBOARD



DISTRICT NON-MPS WITH LV SWITCHBOARD WITH RING MAIN UNIT

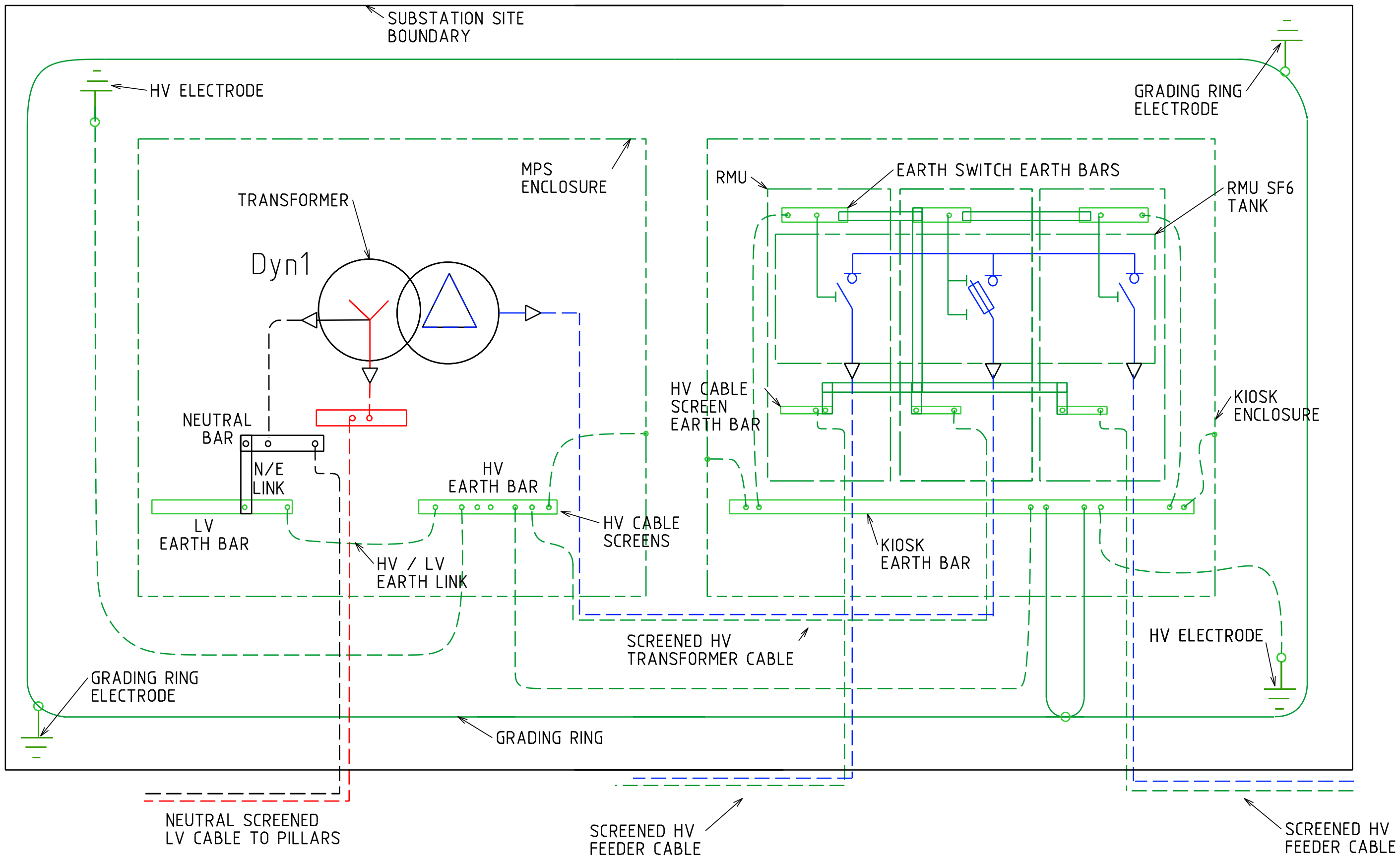


DISTRICT MODULAR PACKAGE SUBSTATION



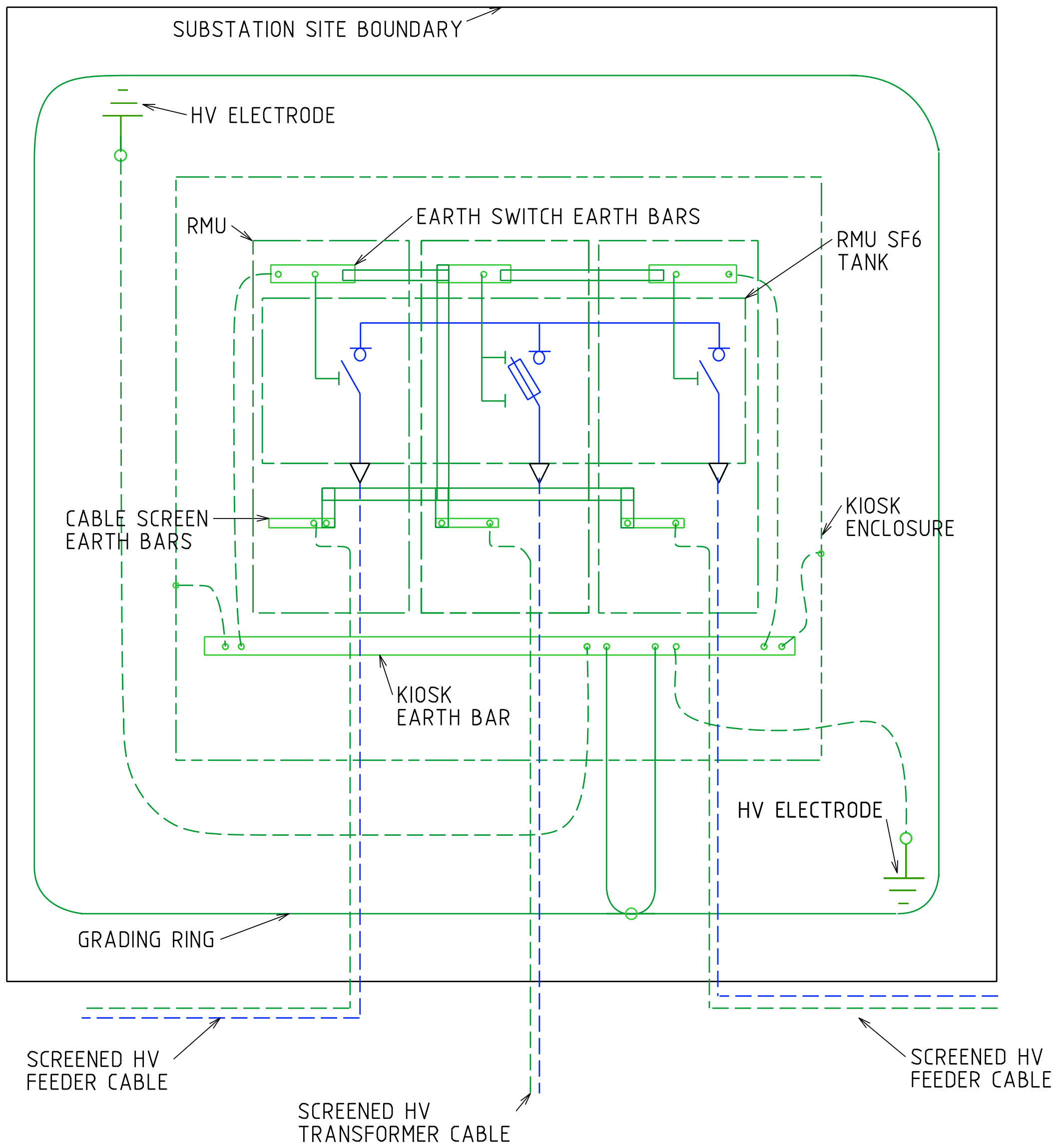
Note that the Modular Packaged Substation (MPS) requires 2 additional electrodes connected to the grading ring. These grading ring electrodes consist of a single 1.5m long earth stake and do not have a target earth resistance.

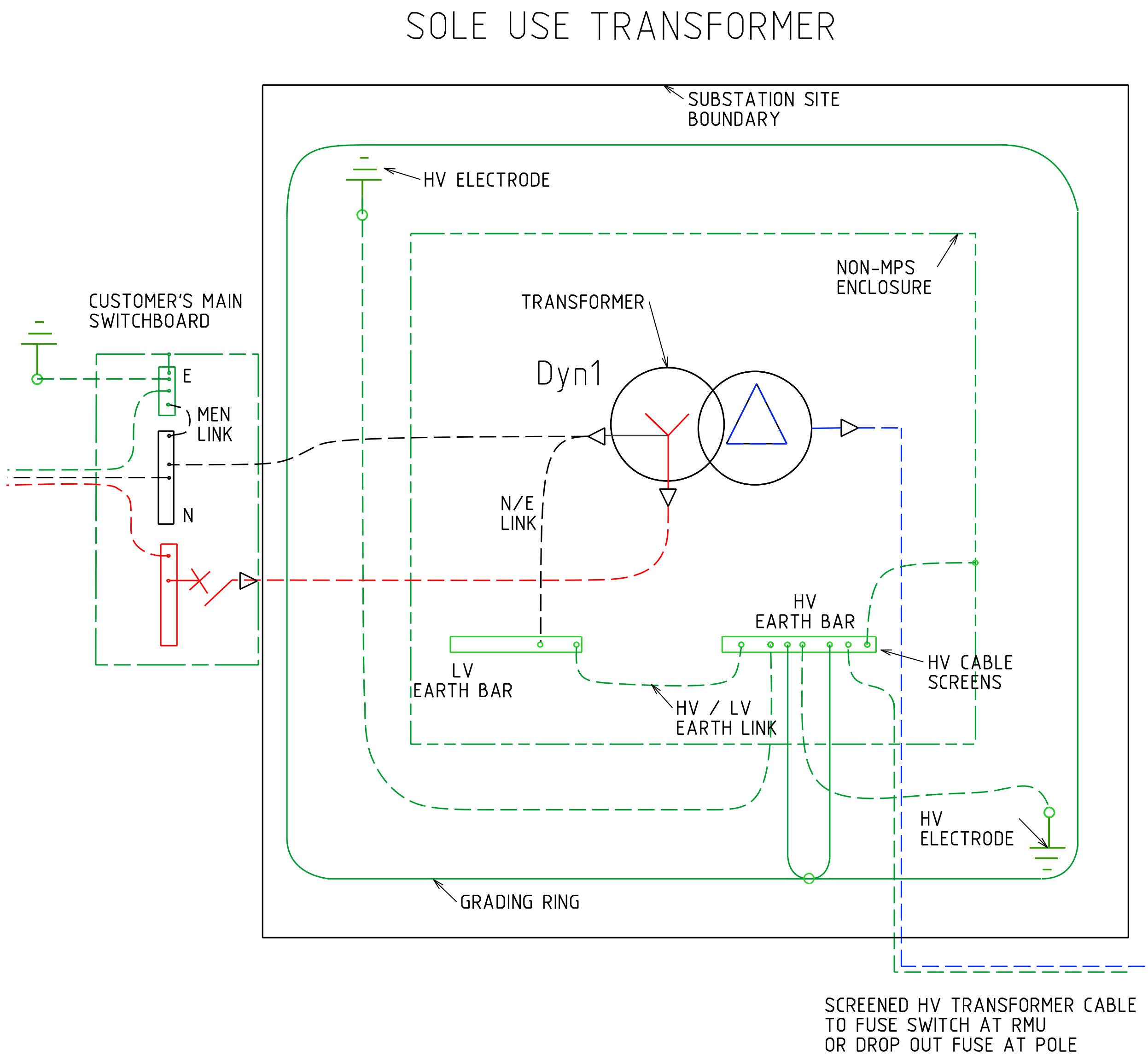
DISTRICT MODULAR PACKAGE SUBSTATION WITH RING MAIN UNIT



Note that the Modular Packaged Substation (MPS) requires 2 additional electrodes connected to the grading ring. These grading ring electrodes consist of a single 1.5m long earth stake and do not have a target earth resistance

RING MAIN UNIT




SOLE USE TRANSFORMER
SUBSTATION SITE BOUNDARY
HV ELECTRODE
NON-MPS ENCLOSURE
CUSTOMER'S MAIN SWITCHBOARD
TRANSFORMER
Dyn1
E
MEN LINK
N
N/E LINK
HV EARTH BAR
HV CABLE SCREENS
LV EARTH BAR
HV / LV EARTH LINK
HV ELECTRODE
GRADING RING
SCREENED HV TRANSFORMER CABLE TO FUSE SWITCH AT RMU OR DROP OUT FUSE AT POLE

SOLE USE TRANSFORMER WITH RING MAIN UNIT