Eskom	Standard	Technology

Title: **INSTALLATION AND COMMISSIONING OF POWER ELECTRONICS EQUIPMENT**

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Content

Figures

1. Introduction

This document specifies the procedure to be followed during installation and commissioning of battery chargers, inverters, converters and UPS systems.

2. Supporting clauses

2.1 Scope

The document formalizes the procedure for installation and commissioning of Power Electronic Equipment to be performed in a safe and reliable manner, the using and distributing of the formalised documentation.

2.1.1 Purpose

This procedure details the requirements for installation, acceptance and commissioning of Power Electronic Equipment within Eskom.

2.1.2 Applicability

This document shall apply throughout Eskom Holdings Limited Divisions.

2.2 Normative/informative references

Parties using this document shall apply the most recent edition of the documents listed in the following paragraphs.

2.2.1 Normative

[1] 240-53114248 Thyristor and Switch Mode Chargers, AC/DC to DC/AC Converters and Inverter / Uninterruptible Power Supplies Standard.

[2] 240-86973501 Engineering Drawing Standard Common Requirements

[3] ISO 9001 Quality Management Systems.

2.2.2 Informative

[4] ***Manufacturer's procedures and manuals

2.3 Definitions

2.3.1 General

Definition	Description
Buck/Boost	A buck–boost converter is a type of DC-to-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude.
Cold Commissioning	All commissioning functions that must be performed before equipment is electrically energised.
Delay Bridge	A 12-pulse charger has two 6-pulse bridges feeding from a Star-Star and Star-Delta configured transformer. The Star-Delta configuration cause a 30° lagging phase shift and therefore the firing pulses are delayed hence the bridge feeding from the Star-Delta is referred to as the delay bridge.

Definition	Description
Dip Proof Inverter	An inverter supplying the control supply of a large AC distribution board. The purpose is to keep the control supply stable during short power dips preventing contactors and relays de-energizing as a result of the dip.
Primary Bridge	A 12-pulse charger has two 6-pulse bridges feeding from a Star-Star and Star-Delta configured transformer. The Star-Star configuration is leading the Star-Delta with 30° and therefore the main firing pulses are derived from the Star-Star configuration hence the bridge feeding from the Star-Star is referred to as the Primary bridge.
Wrap-around	It is a similar circuit to the manual bypass of a UPS but it is completely separate from the UPS system to bypass the complete UPS by connecting the input supply to the output. The purpose is there to be able to exchange A UPS without isolating the load.

2.3.2 Disclosure classification

Controlled disclosure: Controlled disclosure to external parties (either enforced by law, or discretionary).

2.4 Abbreviations

Abbreviation	Description
A	Amp
AC	Alternating Current
AH	Amp Hour
AKZ	*Anlagenkennzeichnungs*system (Plant coding system)
DB	Distribution Board
DC	Direct Current
DPI	Dip Proof Inverter
FAT	Factory Acceptance Testing
HZ	Hertz
kA	Kilo Amp
KKS	Kraftwerk Kennzeichen System
LED	Light Emitting Diodes
M8	Metric bolt 8 millimeters
mA	Milliamps
MCB	Miniature circuit breaker
mS	Millisecond
MΩ	Mega Ohm's
N/A	Not Applicable
PC	Personal Computer

Abbreviation	Description
PPE	Personnel Protective Equipment
Ref.	Reference
RFI	Radio Frequency Interference
RMS	Root Mean Square
SAT	Site Acceptance Testing
SCR	Silicon controlled rectifier
SMR	Switch Mode Rectifier
Snr	Senior
UPS	Uninterruptable Power Supply
V	Volt
Ω	Ohm's

2.5 Roles and responsibilities

Eskom personnel responsible for Power Electronic Equipment shall ensure that this standard is adhered to during installation and commissioning.

2.6 Process for monitoring

a) Technical audits

b) Peer reviews

c) Incident investigation's

2.7 Related/supporting documents

Due to commonalities in the power electronic equipment's commissioning procedures this document will consolidate and replace the following procedures:

a) 240-56178099 - Battery charger Installation and Commissioning Manual

b) 240-80176791 – Secondary Plant Commissioning of DC Power Equipment (Only covered battery chargers)

c) DMN_34-1722 – Battery Charger Installation and commissioning Task Manual (Only covered chargers)

To eliminate duplication and to standardise procedures of Power Electronics Equipment this document also replace the portions applicable to Battery Chargers, DC-DC converters, Inverters and UPS's of the following document:

a) 240-108614750 – Acceptance and Commissioning of DC Supply Equipment

Power electronics commodities added to this document that was previously not addressed in any commissioning standard is as follow.

a) Converters

b) Inverters

c) Uninterruptible Power Supplies

3. Procedure

3.1 Planning

a) There are a few installation methods that can be followed when installing or replacing Power Electronic Equipment. These methods are based on personnel safety, integrity of load equipment and system configuration.

b) Before any installation is done the method to be used shall be agreed upon between all parties involved. This agreement will include a detailed risk assessment with all stakeholders that is involved. The project supervisor will draw up a detailed work schedule and shall be presented to the asset owner system/project engineer for approval. This document will be followed and each activity signed off during installation and commissioning. If an activity cannot be executed on site for any reason an amendment can be made. The detail of the amendment must be documented and agreed upon by the project supervisor and the asset owner's representative on site.

c) It must be strived to use the safest installation method. When determining the safest method start with method 1, if it does not fit the situation the next method must be considered.

3.1.1 Installation Methods for Battery Chargers and DC to DC converters

3.1.1.1 Method 1: New installations

All supplies to the new equipment are isolated and the loads are not commissioned. For these installations no standby back-up system is needed.

a) As per the room layout drawing place and bolt the equipment in place.

b) If there is buss wiring needed between dual equipment and/or DC distribution boards connect these wires as per manufacturer's drawings.

c) Equipment that was removed for transportation must be assembled and installed as per manufacturer's drawings.

d) Install all cables (Input supply, alarm and load cables) as per cabling drawings but do not terminate.

e) Do Insulation Resistance test on equipment and all cables as per Clause 3.5.2 excluding alarm cable.

f) Connect all cables (Input supply, alarm and load cables) as per cabling drawings.

g) Commission equipment as per clause 3.4.1.

3.1.1.2 Method 2: Total system outage

All load circuits can be isolated at the same time. If all the load circuits are isolated all the input supplies can be isolated. For these installations no standby back-up system is needed.

a) As soon as the loads and supplies are isolated and if applicable the permit are in place, disconnect all input, and output cables.

b) Uninstall the old equipment.

c) As per the room layout drawing place and bolt the new equipment in place.

d) If there is buss wiring needed between dual equipment and/or DC distribution boards connect these wires as per manufacturer's drawings.

e) Equipment that was removed for transportation must be assembled and installed as per manufacturer's drawings.

f) Install all cables (Input supply, alarm and load cables) as per cabling drawings but do not terminate.

g) Do Insulation Resistance test on equipment and all cables as per Clause 3.5.2 excluding alarm cable.

h) Connect all cables (Input supply, alarm and load cables) as per cabling drawings.

i) Commission equipment as per clause 3.4.1.

3.1.1.3 Method 3: One load isolated for restricted time

For these installations a standby back-up system is needed. When considering the back-up standby system it must be of the similar or bigger in output capacity than the existing system. If possible the back-up standby system must also be the same configuration as the installed system (dual installed system it must be a dual back-up standby system). When a dual system is replaced the installed cables and battery can be utilised for the transfer.

Note. If a dual system is not practically possible the increased risk for the duration of the installation must be acceptable by all parties.

Note. In clause 3.1.1.3 all reference to battery is only applicable to battery charger systems and not DC to DC converters

a) Install the back-up standby system in an appropriate location.

b) On the existing system use the manufacturer's procedure and transfer the load so that the load is fed by one system.

c) On the existing system isolate the input supply and battery from the equipment that is isolated from the load.

d) Connect the input supply, alarm and battery cables from the existing system that is isolated to one of the back-up standby systems. If possible the input supply should be taken from a spare circuit.

e) Commission the standby back-up system, it is important to test the alarms to the appropriate control centres.

f) Isolate one load at a time, ensure the correct load is isolated and connect this load to the back-up standby system and energise the circuit. Ensure load has started up and record the connection position on the back-up system before moving to the next load.

g) On completion of moving all loads to the back-up standby system the remaining existing system can be isolated and its input supply, battery and alarm cables moved to the second back-up standby system.

h) Commission the second back-up standby system and test alarms to the appropriate control centre.

i) On the standby system transfer load to normal so that a dual redundant system are in place for the remainder of the work.

j) Uninstall the old existing equipment.

k) As per the room layout drawing place and bolt the new equipment in place and assemble and install as per manufacturer's drawings.

l) If there is bus wiring needed between dual equipment and/or DC distribution boards connect these wires as per manufacturer's drawings.

m) Equipment that was removed for transportation must be assembled and installed as per manufacturer's drawings.

n) Install new supply, battery and alarm cables or re-use the old existing cables where posable.

o) Before connecting all cables do an Insulation Resistance test on the equipment and cables as per Clause 3.5.2.

p) Commission the new equipment as per clause 3.4.1.

q) At this stage the one by one load can be isolated and reconnected to the newly installed system.

r) In a dual system the where the cables are re-used the cables can be disconnected from the standby system and connected to the second newly installed system.

s) The second newly installed equipment must be commissioned as per clause 3.4.1.

3.1.1.4 Method 4: Load cannot be isolated

For these installations a back-up standby system is needed with the same conditions as described in method 3. The second condition for these types of installations it must be totally safe to connect the back-up standby system to the load safely while it is alive. If this is not possible the installation must revert to method 3.

Note. If a dual system is not practically possible the increased risk for the duration of the installation must be acceptable by all parties.

Note. In clause 3.1.1.4 all reference to battery is only applicable to battery charger systems and not DC to DC converters

a) Install the back-up standby system in an appropriate location.

b) On the existing system use the manufacturer's procedure and transfer the load so that the load is fed by one system.

c) On the existing system isolate the input supply and battery from the equipment that is isolated from the load.

d) Connect the input supply, alarm and battery cables from the existing equipment that is isolated to one of the back-up standby systems. If possible the input supply should be taken from a spare circuit.

e) Commission the standby back-up system, important to test the alarms to the relevant control centre.

f) Connect a temporary cable from a MCB on the back-up standby system.

g) Connect the other side of the temporary cable to the first load that needed to be transferred.

h) Ensure that the polarity is correct and the voltage difference is less than 5 volts before the temporary cable are made alive by switching the MCB on.

i) At this stage the load are fed in parallel by the back-up standby system and the existing charger.

j) The load that are fed by both systems can now be disconnected from the old system each polarity insulated individually, moved and reconnected on the back-up standby system.

k) Record the connection position of the load on the back-up standby system.

l) Ensure polarities are correct and switch on. During the entire process monitor the loads that all stay alive.

m) The temporary cable can now be isolated and disconnected from the load to be used on the second load needed to be transferred.

n) Repeat the procedure from g) to m) until all loads are transferred to the back-up standby system.

o) The remaining existing system can be isolated and its input supply, battery and alarm cables moved to the second back-up standby system.

p) Commission the second back-up standby system and test alarms to control.

q) On the standby system transfer load to normal so that a dual redundant system are in place for the remainder of the work.

r) Uninstall the old existing equipment.

s) As per the room layout drawing place and bolt the new equipment in place.

t) If there is buss wiring needed between dual equipment and/or DC distribution boards connect these wires as per manufacturer's drawings.

u) Equipment that was removed for transportation must be assembled and installed as per manufacturer's drawings.

v) Install new supply, battery and alarm cables or re-use the old existing cables where posable.

w) Before connecting all cables do an Insulation Resistance test on the equipment and cables as per Clause 3.5.2.

x) Commission the new equipment as per clause 3.4.1.

y) At this stage the procedure as described from g) to m) can be followed to transfer all the loads back from the back-up system to the new installed system.

z) After the loads are transferred to the new existing system the second new installed equipment must be commissioned as per clause 3.4.1.

3.1.2 Installation Methods for Uninterruptable Power Supplies and Inverters

3.1.2.1 Method 1: New installations

a) All supplies to the new equipment are isolated and the loads are not commissioned. For these installations no standby back-up system is needed.

b) As per the room layout drawing place and bolt the equipment in place.

c) If there is buss wiring needed between dual equipment and/or distribution boards connect these wires as per manufacturer's drawings.

d) Equipment that was removed for transportation must be assembled and installed as per manufacturer's drawings.

e) Install all cables (Input supply, alarm and load cables) as per cabling drawings but do not terminate.

f) Do Insulation Resistance test on equipment and all cables as per Clause 3.5.2 excluding alarm cable.

g) Connect all cables (Input supply, alarm and load cables) as per cabling drawings.

h) Commission the equipment as per clause 3.4.1.

3.1.2.2 Method 2 Total system outage

All load circuits can be isolated at the same time. If all the load circuits are isolated all the input supplies can be isolated. For these installations no standby back-up system is needed.

a) As soon as the loads and supplies are isolated and if applicable the permit are in place, disconnect all input, and output cables.

b) Uninstall the old equipment.

c) As per the room layout drawing place and bolt the new equipment in place.

d) If there is buss wiring needed between dual equipment and/or distribution boards connect these wires as per manufacturer's drawings.

e) Equipment that was removed for transportation must be assembled and installed as per manufacturer's drawings.

f) Install all cables (Input supply, alarm and load cables) as per cabling drawings but do not terminate.

g) Do Insulation Resistance test on equipment and all cables as per Clause 3.5.2 excluding alarm cable.

h) Connect all cables (Input supply, alarm and load cables) as per cabling drawings.

i) Commission the equipment as per clause 3.4.1.

Method 3 One load isolated for restricted time

For these installations a standby back-up system is needed. When considering the back-up standby system it must be of the similar or bigger in output capacity than the existing system. If possible the back-up standby system must also be the same configuration as the installed system (dual installed system it must be a dual back-up standby system). When a dual system is replaced the installed cables and battery can be utilised for the transfer.

Note. If a dual system is not practically possible the increased risk for the duration of the installation must be acceptable by all parties.

a) Install the back-up standby system in an appropriate location.

b) On the existing system use the manufacturer's procedure and transfer the load so that the load is fed by one system.

c) If the battery voltage of the back-up system is the same as the current installation and the intension is to use it for the period then on the existing system isolate the input supply and battery from the equipment that is isolated from the load. If the back-up equipment has a different DC voltage then the temporary battery also needs to be assembled in a safe location and be connected to the back-up equipment.

d) Connect the input supply (main and bypass), alarm and battery cables from the existing system that is isolated to one of the back-up standby systems. If possible the input supplies should be taken from spare circuits.

e) Commission the standby back-up system, it is important to test the alarms to the appropriate control centres.

f) Isolate one load at a time, ensure the correct load is isolated and connect this load to the back-up standby system and energise the circuit. Ensure load has started up and record the connection position on the back-up system before moving to the next load.

g) On completion of moving all loads to the back-up standby system the remaining existing system can be isolated and its input supplies, battery and alarm cables moved to the second back-up standby system.

h) Commission the second back-up standby system and test alarms to the appropriate control centre.

i) On the standby system transfer load to normal so that a dual redundant system are in place for the remainder of the work.

j) Uninstall the old existing equipment.

k) As per the room layout drawing place and bolt the new equipment in place and assemble and install as per manufacturer's drawings.

l) If there is bus wiring needed between dual equipment and/or distribution boards connect these wires as per manufacturer's drawings.

m) Equipment that was removed for transportation must be assembled and installed as per manufacturer's drawings.

n) Install new supply, battery and alarm cables or re-use the old existing cables where posable.

o) Before connecting all cables do an Insulation Resistance test on the equipment and cables as per Clause 3.5.2.

p) Commission the new equipment as per clause 3.4.1.

q) At this stage one by one load can be isolated and reconnected to the newly installed system.

r) In a dual system where the cables are re-used the cables can be disconnected from the standby system and connected to the second newly installed system.

s) The second newly installed equipment must be commissioned as per clause 3.4.1

3.1.3 Quality and Factory Acceptance Testing

a) All new equipment that is installed will be tested in the manufacturer's factory before delivery to site or stores.

b) Eskom reserve the rights to witness these tests as per Eskom standard 240-53114248.

c) After FAT the test results must be reviewed and the manufacturer's quality control plan will be signed off by Eskom.

d) The test results must accompany the equipment on delivery.

3.1.4 Engineering

3.1.4.1 Drawings and Documentation

a) The Eskom Power Electronics section must have a complete set of drawings and manuals for the equipment that form part of their responsibility.

b) To perform installation and commissioning the following drawings and manuals are needed:

- Room lay out.
- Cable block diagram and/or cable schedule.
- Equipment and Distribution board general arrangement drawings.
- Equipment and Distribution board schematic drawings.
- Equipment operational manuals.

c) Engineering or design need to supply these drawings and manuals well in advance to give installation personnel enough time to review the documents.

d) The latest revisions of the relevant drawings must be used to confirm all connections and testing points.

e) If wire changes are done on any part of the plant, or any part of the plant are not according to the drawings the drawings must be marked-up using yellow and red according Eskom drawing standards.

3.1.4.2 Settings

a) The purpose of the settings sheet is to formalise an official set of settings for equipment that must be used during maintenance and commissioning.

b) Engineering or design is responsible to complete and approve a settings sheet as per the Power Electronics Equipment Settings Standard for the new equipment.

c) The approved settings sheet must be supplied to the installation personnel prior to the project commence.

d) Customisation of settings must be marked up on settings sheet during commissioning by commissioning team and sent to engineering or design for approval on completion of project.

3.2 Safety

3.2.1 Plant Safety

a) All work in Eskom on an industrial plant must be performed under a Permit to Work.

b) Where any manipulation of installations or temporary connections / disconnections is required to obtain access to take measurements, it is advisable to first inform the control centre of a risk of trip. Then it is also advisable to obtain written permission from the control centre to continue despite the risk of trip.

c) Before any work can commence all alarms on the plant need to be cleared.

d) Where necessary perform Hazard Identification and follow Risk Assessment Methodology.

3.2.2 Personal Safety

a) At all times personnel safety and installation security will enjoy priority over test measurements.

b) Personnel must adhere to regulations stipulated in the Occupational Health and Safety Act, and must also adhere to the local safety regulations of the station authority where the work is performed.

c) Under no circumstances may manipulation of installations be undertaken so that personnel can make contact with circuits supplied from a low voltage power circuit. If so required these actions will take place in accordance with 36-681 (Generation Plant Safety Regulations) Live work clause and/or working to an alternative safe work procedure. Not all divisions in Eskom make use of the 36-681 (Generation Plant Safety Regulations) and therefore it cannot be followed 100% but all stipulations that can be implemented must be adhered to by Eskom personnel responsible for the work.

d) The latest revisions of the relevant drawings must be used to confirm all connections and testing points.

e) The appropriate PPE to be used as determined in the risk assessment.

3.3 Guidelines on Completion of the Check Sheet

a) Alternative check sheets may be developed by divisions in order to cater for different types of data capture systems as long as it is not inferior to the attached check sheets.

b) All sections of the check sheet must be completed.

c) The check sheet is in a chronological order and must be completed from top to bottom. Current limit settings may be done out of the normal order depending on the procedure use to test this function.

d) Each activity has a number of columns next to it and must be interpreted as follow.

- "Ref. Value" and "Ref. Setting" columns are used to fill in what the value is supposed to be for the activity. If the activity is not a setting but only a value the expected value is filled into this column.
- "Confirm check done" column is used as a confirmation that the activity is completed. If an activity cannot be done or it is not applicable to the specific equipment "N/A" must be entered into this column but a reason must be given in the "Comments" column.
- "Record Value/Condition" column is used to enter the value or condition of the activity that was measured or checked.
- Any setting that is not applicable, could not be checked or is abnormal must have an explanation in the "Comments" column.
- The "Measured Value" column is similar to the "Record Value/Condition" column it is the measured value measured with calibrated test instrument.
- The "Displayed Value" column is to record the value displayed by the charger.
- The "Controlled Value" column is value where the charger is supposed to control.
- The "Operation Value" column is the value at which a specific operation takes place.

e) If the "Displayed Value", "Controlled Value" or "Operation Value" differs more than 0.5% from the "Measured Value" or "Ref. Setting" the setting must be changed or feedback must be calibrated and the new value must be documented.

f) As not all the chargers have the same feedback and display meters a blank space is left below the "Check and calibrate Feedbacks and meters" so that the applicable calibration functions could be populated in this section of the check sheet.

g) As not all equipment has the exact same alarm functions a blank space is left below the "Test operation of alarm & protection circuits" so that the applicable alarms could be populated in this section of the check sheet. Timer settings and all other control functions also form part of this section.

h) On completion of any check sheet it must be signed off. The signed document must be stored as prescribed by the division's processes.

3.4 Installation Procedure for Power electronics equipment

3.4.1 Documentation, Tools and equipment needed

a) Relevant Procedures, Check Sheets, Setting Sheets, Manuals and Drawings

b) Technicians toolbox

c) Proper hammer drill (if applicable)

d) Large Angle grinder (if applicable)

e) Rawl Bolts or other fasteners applicable to installation

f) Blower and/or vacuum cleaner

g) Feather duster

h) Cloth

i) Paint brush

3.4.2 Installation

a) Power electronics equipment panel must be placed in the equipment room according to equipment room layout drawing.

b) Panels must be aligned to all other panels in the room.

c) Panels must be fixed to the floor or room structure in an approved method to prevent the panel from moving

- Concrete floor rawl bolts are used.
- On false floors like computer or telecommunication rooms special brackets is used.
- Across cable trenches rawl bolts are used or in older rooms a fastening channels are installed in the floor.

d) When a panel is mounted over a cable trench the trench covers need to be cut to size in order to cover the trench completely.

e) After the panel is mounted properly the panel and working area must be cleaned.

3.5 Commissioning Procedures

3.5.1 Documentation, Tools and equipment needed

a) Relevant Procedures, Check Sheets, Setting Sheets, Manuals and Drawings

b) Laptop (optional depending on type of equipment)

c) Insulation Resistance meter (500V Megger)

d) Scope meter

e) Multi meter

f) Amp probe/meter

g) Variac (optional depending on type of equipment) or variable AC supply

h) Power supply (optional depending on procedure for alarm settings)

i) External load bank (optional depending on procedure for current limit settings)

3.5.2 Insulation Resistance Test

3.5.2.1 Cable Insulation Resistance Test

a) Cables must be disconnected.

b) On one side of the cable connect all cores of a cable together and link down to earth.

Note. (Use a cable strand or a strand of armouring and wrap from on core to the next and wrap until all cores are connected and then rap to a earth)

c) On the other side of the cable connect the Insulation resistance tester between earth and first core of the cable and test (Minimum test voltage of 100V not more than 500V)

d) At this stage the Insulation resistance tester should test 0Ω. If not 0Ω then:

- Testing is done on the incorrect cable.
- The cable is open circuit.

e) Back at the other side of the cable the core that is tested should be removed by cutting the wrapped connecting wire with an insulated side cutter.

f) The insulation tester reading should increase to at least 2MΩ. If not at least 2MΩ then:

- Testing is done on the incorrect cable.
- Testing is done on the incorrect core of the cable.
- The cable is faulty.

g) Using this method the cable is tested for continuity, correct cable and core number, insulation is tested to earth and insulation is tested to other cores.

3.5.2.2 Equipment Insulation Resistance Test

a) All printed circuit boards or modules with integrated printed circuit boards may be disconnected or removed. (For example In a SMR the rectifiers and the controller must be removed).

b) Remove or disconnect all surge protection and RFI filters.

c) Disconnect any intentional grounding resistors.

d) All semiconductor devices must be bridged out and connected together.

e) Connect all outputs together.

f) Connect all inputs together.

g) All switch gear should be closed or bridged out.

h) Connect the output terminals to earth (equipment enclosure).

i) Connect the Insulation resistance tester between earth and input terminals of the equipment and test (Minimum test voltage of 100V not more than 500V).

j) The insulation tester reading should be at least 2MΩ; insulation of the input circuit is tested as well as the galvanic insulation between input and output.

Note: On the bypass circuit of a UPS or Inverter with no bypass transformer there is no galvanic insulation and therefore the test on that circuit will not be done between input and output.

k) Connect the input terminals to earth (equipment enclosure).

l) Connect the Insulation resistance tester between earth and output terminals of the equipment and test (Minimum test voltage of 100V not more than 500V).

m) The insulation tester reading should be at least 2MΩ; insulation of the output circuit is tested as well as the galvanic insulation between input and output.

n) If at any stage of testing the reading is below 2MΩ the individual circuits must be tested to identify the faulty circuit.

o) On completion of this test all cables must be reconnected, all temporary bridging wires must be removed and all internal equipment that was removed or disconnected must be replaced and connected.

3.5.3 Power Electronics Equipment cold commissioning

a) Complete the information section of the check sheet.

b) If applicable transfer the loads and remove the old equipment and install the new equipment as per 3.1.1 or 3.1.2 and 3.4

c) By using a blower and/or vacuum cleaner remove all dust and debris from charger cubicle. Dust that is sticky can be removed with a feather duster, dry cloth or paint brush. Do not brush or blow dust into protection relays, control equipment or switchgear mechanisms. By using a paint brush to remove dust special attention must be given to all electronic cards. Excessive dust will cause flashovers, electrical tracking, insufficient cooling and overheating in power electronic equipment. It also causes excessive wear in any movable components like fans, contactors and switches. Also clean the equipment cabinet externally.

d) Inspect that all labelling are correct and mounted properly.

- The name plate must indicate the dedicated name of the power electronics equipment and where AKZ or KKS numbers are used it must also be displayed.
- Rating plate must at least indicate the manufacturer's name or logo, manufacturer's type number, date of manufacture, manufacturer's serial number, rated AC/DC input voltage and tolerance band, rated AC/DC input current, input/output number of phases, rated frequency, rated AC/DC output voltage, and the rated AC/DC output current or Power.
- Fuses and MCB’s must be labelled according to drawing and fuse labels must include its rating.
- Switch gear must be labelled according to drawing and all switch gear must also clearly indicate the open and close positions.
- All the components in the power electronics equipment panel must be clearly labelled according to the drawing.
- All cables and terminals must be labelled according to 0.00/10335 sheet 1-4
- The standard danger notice shall be prominently displayed outside of the enclosure or on the inside on the safety barriers protecting all live parts.

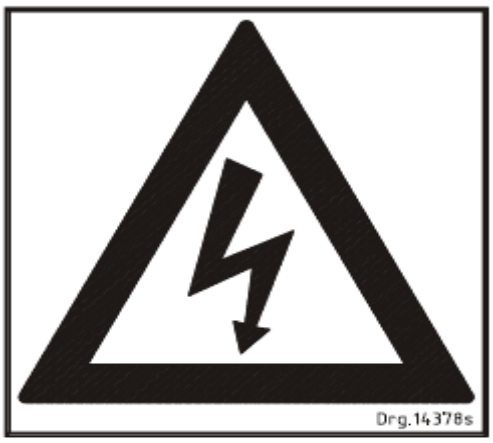

Figure 1: Danger notice sign

e) Inspect that the equipment is securely mounted to the floor and all equipment in the cubicle are still securely mounted. Any lose components in an equipment panel are a safety risk and must be secured properly.

f) Check all the connections for tightness. It is good practice to use appropriate tools to ensure all terminations are secure. Any lose connections found must be recorded and re-torqued. As a standard all electrical connection bolts larger than M8 must be torqued and marked.

g) Visually inspect all the components inside the equipment panel for any damages or cracks that could have occurred during transportation. Any damages found must be recorded, investigated to prevent re-occurrence and thereafter repaired.

h) Visually inspect all earths for correctness and integrity. “Earths are very important for the safety of humans and equipment. Earths are there to drain any surges or lightning directly to earth by providing a path of lowest resistance instead of the surge dissipating thru components of the equipment or human contact with the equipment to earth”.

- Ensure that there is an earth connected to the station earth.
- The best practice is for the equipment to be Faraday earthed. The station earth must be connected to the equipment panels casing and from that connection connected to the earth bar and other earth points. This method ensure that any noise generated by surges stay on the outside of the equipment panel effectively creating a Faraday cage. If the earth comes into the panel through a gland the noise generated by the surge can affect any electronic functions.
- All individual none current carrying metal parts must be connected to earth.
- All surge protection must be connected to earth.
- All RFI protection must be connected to earth.
- In floating DC systems inspect the centre tap of the earth fault monitor to be connected to earth. (A floating system is when neither the positive nor the negative is connected to earth usually all 220V and 110V systems are floating systems)
- On DC systems that are earthed inspect that the appropriate pole is connected directly to earth. (An earthed system is when one of the poles is solidly connected to earth in general the 50Vand some 24V systems are positively earthed and some 24V systems are negatively earthed).
- The earth wires can be bare or insulated, if it is insulated it must be green/yellow of colour.

i) Visually inspect all surge protection for correctness. Any faulty surge protection must be replaced immediately. Verify with drawing but in general surge protection can be found:

- Connected on the input of the power electronics equipment.
- Connected on the outputs of the power electronics equipment.
- Across the converter bridges (Snubber circuits).
- Connected across DC coils.

j) Confirm that all fuse and MCB ratings are according to drawings and labels. If a rating is not on the drawing or on a label in the panel it must be in the manufacturer’s manual under components list. Important to check the current, voltage, short circuit (kA) and type (fast, slow blow).

k) Note: This section is probably applicable to older type equipment as most of the modern equipment makes use of digital displays. Zero all display meters. Analogue meters must be used for display only. It is important to indicate 0A or 0V. After confirming with a multi-meter that voltage and currents are at a zero value the charger’s analogue meters can be set to zero. These types of meters cannot be calibrated in the field and therefore only use it as indication. Important “do not use” the zero screw to try and calibrate as then it will not indicate zero. The indication from this meter you need are there V or A, +/- the value of V or A not the exact value.

Figure 2: Analogue Meter

3.5.4 Phase Controlled Battery Chargers

For standard check sheet see Annex A

Notes:

1) For first time start-up the manufacturer's start-up procedure should be followed.

2) The procedure is based on microprocessor controlled chargers only. If a commissioning procedure is needed for an old analogue charger the maintenance procedure in the maintenance task manual can be followed.

a) At this stage all isolators and MCB's must be in the open position.

b) Once the project schedule has been signed off to this point of commissioning and all cables have been tested and safety clearances issued then switch the AC supply on and measure AC supply voltage on top of the AC supply breaker, each phase to neutral or earth and neutral to earth. The typical value must be close to 220V +/- 20% and neutral to earth value must be very close to zero. If voltage is out of tolerance investigate supply, if neutral to earth is higher than 1V the neutral are floating and must be rectified at supply.

c) Close the AC supply breaker and the control supply breaker. Ensure all control circuits start up. (Displays will start up and indication LED's will illuminate).

d) On the display ensure that all the measured values are at zero if not zero all measured values.

e) Ensure that all settings entered into the charger control system are as per settings document and rectify if there are any discrepancies. Attach to the check sheet the settings sheet that was used for verification.

f) Connect a light dummy load to the charger (dummy load = 1% to 10% of charger rating) clear alarms and start the charger.

g) Before closing the battery and load isolators check the polarity to be correct.

h) Measure the transformer output voltage phase to phase. It is important that all the phases are balanced. On a 12-pulse charger the primary bridge's 3 phases and the delay bridge's 3 phases must be balanced (6 phases in all). If all phases are not balanced it can be that the input is unbalanced, a damaged transformer or a faulty controls.

i) Measure if AC phases current are balanced, this measurement must be measured with an AC current probe on the output of the main transformer or the input of the rectifier bridges. For a 6-pulse rectifier there are 3-phases and a 12-pulse rectifier there are 6-phases. If all phases are not balanced it can be that the controls are faulty. Microprocessor chargers will actively adjust the phases firing angles continuously to keep the phases balanced.

j) One channel of a scope meter must be connected across the DC output of the rectifier bridge before the filter circuit. On a 12-pulse charger a second channel of the scope meter must be connected across the second rectifier bridge. The cannels of the scope meter must be set to AC coupling, the time base to 2mS per division and the voltage is dependent on the output voltage of the charger. See waveform displayed below of a 6 pulse secondary controlled rectifier. Save this waveform and attach it to the check sheet as proof that this test was done. It can be seen that there are 6 waves in 20mS with a 12-pulse charger there will be 12 waves all phase shifted by 30°. All the waves must look similar and the amplitudes must be equal. On a primary controlled charger the waveform will look slightly different. If there are waves missing or the amplitudes are not equal the fault must be traced and rectified. Common faults are faulty firing (control card) or faulty SCR. If this is not rectified charger ripple voltage will be high and it will damage the batteries.

Note: It is more accurate to do all measurements described in g) to j) with a higher load between 10% and 100% of charger capacity.

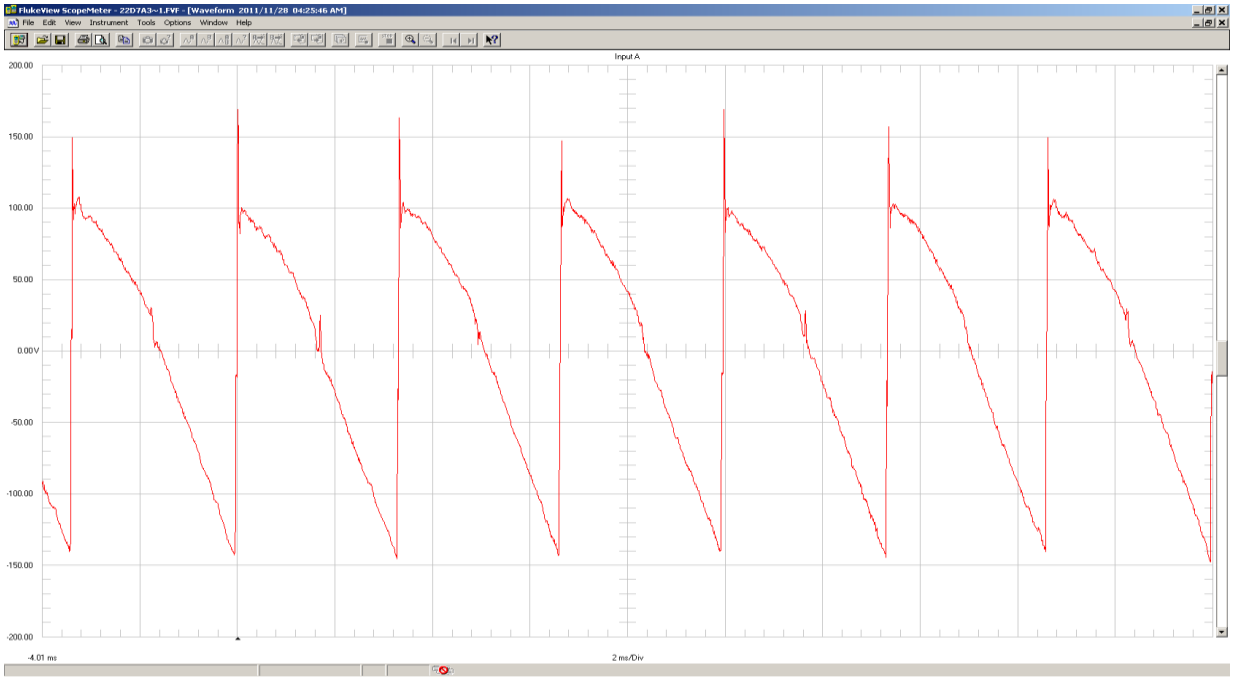

Figure 3: Scope Measurement across SCR Bridge

k) Measure and record the DC voltage from positive to earth and from negative to earth. These two values must be close to equal on a floating system. If it is equal it means there are no earth faults. If the values are not equal there is an earth fault, on dual chargers if both chargers have earth faults there is a high risk transferring or paralleling the loads as the earth faults can cause short circuits. Any earth fault is a high risk and must be cleared as soon as possible as the second earth fault can cause a short circuit that can cause trip coils or protection relays to operate.

l) Record the calibration of all analogue inputs/feedbacks of the battery charger. The specific manufacturer's procedure must be followed. The general procedure is to measure the analogue input/feedbacks and adjusting the corresponding calibration setting until the displayed value is equal to the measured value.

m) Test operation of all alarm and protection circuits. This section must be populated with the specific charger's alarm and protection settings including all timer settings. It is important to note that monitoring of circuit breakers and fuses also form part of these tests. The settings must be obtained from the settings sheet.

- The operation of most of the alarm functions can be verified by varying the output voltage of the battery charger until the alarm function operate, record this operating value. The output voltage can be varied by changing the float or boost setting or by injecting a voltage on the output with a variable power supply.
- **Very important do this test only on floating systems with no earth faults.** The earth fault circuit can be tested by connecting a suitable variable resistor (dependant on charger a 5 to 10 kΩ, 5 Watt) in serious with a multi-meter set to mA DC scale. The multi-meter and resister must then be connected between the positive and earth and negative and earth in turn. Adjust the variable resister until the earth fault alarm is initiated and record the current measurement and the voltage across the circuit. The current must be close to 10mA. Some chargers has a time delay on this alarm so as the variable resister is adjusted when 10mA is reached stop and wait 10 to 30 seconds to see if the alarm react before going higher.
- Monitoring of the switch gear is tested by operating it.
- Other monitoring circuits that cannot be operated (fuse, surge arrestors and temperature) can be tested by disconnecting or bridging its auxiliary circuit.
- If any of the alarm or function settings are not set correctly it can cause a malfunction of the charger which can lead to equipment damage, load loss and injury to humans.
- During the whole procedure described ensure that all alarms are displayed on the charger display panel. If alarms are not displayed the fault must be traced and repaired. Alarms displayed on the charger display panel guides technicians when doing fault finding.
- **Very important:** On completion of testing the alarms phone the control centre and ensure that they did receive all the alarms and that all the alarms have cleared. If alarms are not received or did not clear, test the output of the alarm relay card. If the charger relay card is operating correctly report fault and ensure that the fault are resolved. If possible obtain a copy of the alarm/event log from the control centre and attach it to the check sheet as proof that the alarms were tested.

Note: When doing the dropping and blocking diode test as per n) to p) below there must be a small load connected to the load terminals or at least on the output of the dropping diodes.

n) If the charger is fitted with dropping diodes to regulate the voltage to the load the operating settings can be tested as described in m) above. Test the full functionality of the dropping diodes by ensuring all stages energise and de-energise while ensuring that the load voltage are kept within the load limits, record the minimum and maximum load voltage. If the limits are bridged the setting need to be changed or the number of diodes must be adjusted.

o) Record the volt drop across each dropping diode stage by measuring the difference between the battery and loud voltages. The volt drop across each stage must be compared to the amount of diodes fitted multiplied by +/- 0.6V to 1V. If the values are lower than calculated the individual diodes must be tested for short circuits and replaced.

p) Measure and record the volt drop across all blocking diodes. Blocking diodes are usually used where multiple chargers supply is combined to supply one load to prevent one charger feeding into the other chargers via the load circuit. The value must be between 0.4V to 1.4V. If the value is 0V the diode is short circuited and must be replaced. If the value is very high it means the diode is open circuit and must be replaced before attempts are made to transfer the load to that charger as the load will be compromised.

q) Verify current limit settings using an external load bank or a discharged battery: Shut down the battery charger and connect an appropriate sized load bank or a discharged battery to the battery output of the battery charger. NB if the charger has a total charger current limit the float current limit must be increased so that the total current limit can be obtained without the float current limit affecting it. Measure the output voltage and current. Adjust external load and observe when the output voltage start to decrease at that stage the current measurement will be equal to the current limit setting. When connecting a discharged battery the output voltage will immediately decrease and the output current will stay constant, this constant current will be equal to the current limit setting. Repeat procedure for each charging mode. Always start with the highest current limit setting down to the lowest. If the current limit settings are incorrect the current calibration must be verified or the control card is faulty. On completion disconnect the dummy load or the discharge battery.

r) Verify the charging mode voltages by selecting the charger to the applicable charging modes and recording each voltage value. If the measured values are not corresponding to the settings the voltage calibrations must be verified or the control card is faulty.

Note: Bear in mind that some chargers may have compensation factures (temperature compensation, volt drop compensation) that can influence the output voltage these functions should be disabled when verifying the charging mode voltages.

s) On dual charger systems test the operation of the load transfer switch.

t) Ensure that the charger is in a normal working state, all settings and functions that were changed for test purposes must be returned to normal and all dummy loads must be disconnected.

Note: The following checks and measurements must be done after the loads are made alive.

u) Measure standing load, this measurement must be measured with a DC current probe on the load output of the charger. This measurement gives an indication on the standby time of the system as well as load sharing on dual systems.

v) Measure ripple voltage, this measurement can be done in 2 ways with a multi-meter or scope meter set to measure AC volts across the battery output terminals of the charger. The typical value must be less than 1% of the charger nominal output voltage and it must be expressed in a Voltage RMS. (Example: On a 220V DC system 1% is 2.2V RMS). If the measurement is higher investigate the following Phase balancing due to input constraints or firing of the SCR Bridges. If Phases are balanced and ripple voltage still too high filter capacitors must be replaced.

w) Measure ripple current, this measurement must be taken with an AC current probe on the battery output of the charger. The typical value must be less than 3% of the battery capacity value. (Example: if there is a 100AH battery connected to the charger the ripple current must be less than 3A). If the measurement is higher investigate the following Phase balancing due to input constraints or firing of the SCR Bridges. If phases are balanced and ripple current still too high investigate filter circuit.

x) Save the final configuration files to be stored for future reference.

y) Capture all test equipment information.

z) If any changes were affected to the drawings or settings ensure the applicable engineering change process is followed to update the design.

3.5.5 Switch Mode Battery Chargers

For standard check sheet see Annex B

a) At this stage all isolators and MCB's must be in the open position.

b) Once the project schedule has been signed off to this point of commissioning and all cables have been tested and safety clearances issued then switch the AC supply on and measure AC supply voltage on top of the AC supply breaker, each phase to neutral or earth and neutral to earth. The typical value must be close to 220V +/- 20% and neutral to earth value must be very close to zero. If voltage is out of tolerance investigate supply, if neutral to earth is higher than 1V the neutral are floating and must be rectified at supply.

c) Close the AC supply breaker and the control supply breaker. Ensure all control circuits start up. (Displays will start up and indication LED's will illuminate).

d) Ensure that all settings entered into the charger control system are as per settings document and rectify if there are any discrepancies. Attach to the check sheet the settings sheet that was used for verification.

e) Connect a light dummy load to the charger (dummy load = 1% to 10% of charger rating) clear alarms.

f) Before closing the battery and load isolators check the polarity to be correct.

g) Measure and record the DC voltage from positive to earth and from negative to earth. These two values must be close to equal on a floating system. If it is equal it means there are no earth faults. If the values are not equal there is an earth fault, on dual chargers if both chargers have earth faults there is a high risk transferring or paralleling the loads as the earth faults can cause short circuits. Any earth fault is a high risk and must be cleared as soon as possible as the second earth fault can cause a short circuit that can cause trip coils or protection relays to operate.

h) Record the calibration of all analogue inputs/feedbacks of the battery charger. The specific manufacturer's procedure must be followed. The general procedure for each of the analogue inputs are to set the analogue to a low value measure the analogue input and adjusting the corresponding calibration setting until the displayed value is equal to the measured value then repeat the procedure with the analogue set to a high value.

i) Test operation of all alarm and protection circuits. This section must be populated with the specific charger's alarm and protection settings including all timer settings. It is important to note that monitoring of circuit breakers and fuses also form part of these tests. The settings must be obtained from the settings sheet.

- The operation of most of the alarm functions can be verified by varying the output voltage of the battery charger until the alarm function operate, record this operating value. The output voltage can be varied by changing the float or boost setting or by injecting a voltage on the output with a variable power supply.
- **Very important do this test only on floating systems with no earth faults.** The earth fault circuit can be tested by connecting a suitable variable resistor (dependant on charger a 5 to 10 kilo ohms, 5 Watt) in serious with a multi-meter set to mA DC scale. The multi-meter and resister must then be connected between the positive and earth and negative and earth in turn. Adjust the variable resister until the earth fault alarm is initiated and record the current measurement and the voltage across the circuit. The current must be close to 10mA. Some chargers has a time delay on this alarm so as the variable resister is adjusted when 10mA is reached stop and wait 10 to 30 seconds to see if the alarm react before going higher.
- Monitoring of the switch gear is tested by operating it.
- Other monitoring circuits that cannot be operated (fuse, surge arrestors and temperature) can be tested by disconnecting or bridging its auxiliary circuit.
- If any of the alarm or function settings are not set correctly it can cause a malfunction of the charger which can lead to equipment damage, load loss and injury to humans.
- During the whole procedure described ensure that all alarms are displayed on the charger display panel. If alarms are not displayed the fault must be traced and repaired. Alarms displayed on the charger display panel guides technicians when doing fault finding.
- Very important: On completion of testing the alarms phone the control centre and ensure that they did receive all the alarms and that all the alarms have cleared. If alarms are not received or did not clear, test the output of the alarm relay card. If the charger relay card is operating correctly report fault and ensure that the fault are resolved. If possible obtain a copy of the alarm/event log from the control centre and attach it to the check sheet as proof that the alarms were tested.

Note: When doing the dropping and blocking diode test as per j) to l) below there must be a small load connected to the load terminals or at least on the output of the dropping diodes.

j) If the charger is fitted with dropping diodes to regulate the voltage to the load the operating settings can be tested as described in i) above. Test the full functionality of the dropping diodes by ensuring all stages energise and de-energise while ensuring that the load voltage are kept within the load limits, record the minimum and maximum load voltage. If the limits are bridged the setting need to be changed or the number of diodes must be adjusted.

k) Record the volt drop across each dropping diode stage by measuring the difference between the battery and loud voltages. The volt drop across each stage must be compared to the amount of diodes fitted multiplied by +/- 0.6V to 1V. If the values are lower than calculated the individual diodes must be tested for short circuits and replaced.

l) Measure and record the volt drop across all blocking diodes. Blocking diodes are usually used where multiple chargers supply is combined to supply one load to prevent one charger feeding into the other chargers via the load circuit. The value must be between 0.4V to 1.4V. If the value is 0V the diode is short circuited and must be replaced. If the value is very high it means the diode is open circuit and must be replaced before attempts are made to transfer the load to that charger as the load will be compromised.

m) Verify current limit settings using an external load bank or a discharged battery: Shut down the battery charger and connect an appropriate sized load bank or a discharged battery to the battery output of the battery charger. NB if the charger has a total charger current limit the float current limit must be increased so that the total current limit can be obtained without the float current limit affecting it. Measure the output voltage and current. Adjust external load and observe when the output voltage start to decrease at that stage the current measurement will be equal to the current limit setting. When connecting a discharged battery the output voltage will immediately decrease and the output current will stay constant, this constant current will be equal to the current limit setting. Repeat procedure for each charging mode. Always start with the highest current limit setting down to the lowest. If the current limit settings are incorrect the current calibration must be verified or the control card is faulty. On completion disconnect the dummy load or the discharge battery.

n) Verify the charging mode voltages by selecting the charger to the applicable charging modes and recording each voltage value. If the measured values are not corresponding to the settings the voltage calibrations must be verified or the control card is faulty.

Note: Bear in mind that some chargers may have compensation factures (temperature compensation, volt drop compensation) that can influence the output voltage these functions should be disabled when verifying the charging mode voltages.

o) On dual charger systems test the operation of the load transfer switch.

p) Ensure that the charger is in a normal working state, all settings and functions that were changed for test purposes must be returned to normal and all dummy loads must be disconnected.

Note: The following checks and measurements must be done after the loads are made alive.

q) Measure standing load, this measurement must be measured with a DC current probe on the load output of the charger. This measurement gives an indication on the standby time of the system as well as load sharing on dual systems.

r) Save the final configuration files to be stored for future reference.

s) Capture all test equipment information.

t) If any changes were affected to the drawings or settings ensure the applicable engineering change process is followed to update the design.

3.5.6 DC to DC Converters

For standard check sheet see Annex C

Note: DC to DC converters commissioning is similar to Switch Mode Rectifiers

a) At this stage all isolators and MCB's must be in the open position.

b) Once the project schedule has been signed off to this point of commissioning and all cables have been tested and safety clearances issued then switch the DC supply on and measure DC supply voltage on top of the supply breaker, record the value and note polarity for correctness.

c) Close the DC supply breaker and the control supply breaker. Ensure all control circuits start up. (Displays will start up and indication LED's will illuminate).

d) Ensure that all settings entered into the converter control system are as per settings document and rectify if there are any discrepancies. Attach to the check sheet the settings sheet that was used for verification.

e) Connect a light dummy load to the charger (dummy load = 1% to 10% of converter rating) clear alarms.

f) Before closing the load isolators check the polarity to be correct.

g) Measure and record the DC voltage from positive to earth and from negative to earth. These two values must be close to equal on a floating system. If it is equal it means there are no earth faults. If the values are not equal there is an earth fault, on dual converter if both converters have earth faults there is a high risk transferring or paralleling the loads as the earth faults can cause short circuits. Any earth fault is a high risk and must be cleared as soon as possible as the second earth fault can cause a short circuit that can cause trip coils or protection relays to operate.

h) Record the calibration of all analogue inputs/feedbacks of the converter. The specific manufacturer's procedure must be followed. There are generally 2 types with the following general procedures.

- Type 1: The general procedure for each of the analogue inputs are to set the analogue to a low value measure the analogue input and adjusting the corresponding calibration setting until the displayed value is equal to the measured value then repeat the procedure with the analogue set to a high value.
- Type 2: The general procedure is to measure the analogue input/feedbacks and adjusting the corresponding calibration setting until the displayed value is equal to the measured value.

i) Test operation of all alarm and protection circuits. This section must be populated with the specific converter's alarm and protection settings including all timer settings. It is important to note that monitoring of circuit breakers and fuses also form part of these tests. The settings must be obtained from the settings sheet.

- The operation of most of the alarm functions can be verified by varying the output voltage of the converter until the alarm function operate, record this operating value. The output voltage can be varied by changing the output setting or by injecting a voltage on the output with a variable power supply.

Note: Be aware some converter modules have a build in blocking diode on its output therefore the injection method will not be a viable option.

- **Very important do this test only on floating systems with no earth faults.** The earth fault circuit can be tested by connecting a suitable variable resistor (dependant on converter a 5 to 10 kΩ, 5 Watt) in serious with a multi-meter set to mA DC scale. The multi-meter and resister must then be connected between the positive and earth and negative and earth in turn. Adjust the variable resister until the earth fault alarm is initiated and record the current measurement and the voltage across the circuit. The current must be close to 10mA. Some converters has a time delay on this alarm so as the variable resister is adjusted when 10mA is reached stop and wait 10 to 30 seconds to see if the alarm react before going higher.
- Monitoring of the switch gear is tested by operating it.
- Other monitoring circuits that cannot be operated (fuse, surge arrestors and temperature) can be tested by disconnecting or bridging its auxiliary circuit.
- If any of the alarm or function settings are not set correctly it can cause a malfunction of the converter which can lead to equipment damage, load loss and injury to humans.

- During the whole procedure described ensure that all alarms are displayed on the converter display panel. If alarms are not displayed the fault must be traced and repaired. Alarms displayed on the converter display panel guides technicians when doing fault finding.
- Very important: On completion of testing the alarms phone the control centre and ensure that they did receive all the alarms and that all the alarms have cleared. If alarms are not received or did not clear, test the output of the alarm relay card. If the converter relay card is operating correctly report fault and ensure that the fault are resolved. If possible obtain a copy of the alarm/event log from the control centre and attach it to the check sheet as proof that the alarms were tested.

Note: When doing the blocking diode test as per j) below there must be a small load connected to the load terminals.

j) Measure and record the volt drop across all blocking diodes. Blocking diodes are usually used where multiple converters supply is combined to supply one load to prevent one converter feeding into the other converters via the load circuit. The value must be between 0.4V to 1.4V. If the value is 0V the diode is short circuited and must be replaced. If the value is very high it means the diode is open circuit and must be replaced before attempts are made to transfer the load to that converter as the load will be compromised.

k) Verify current limit settings using an external load bank. Shut down the converter and connect an appropriate sized load bank to the output of the converter. Measure the output voltage and current. Adjust external load and observe when the output voltage start to decrease at that stage the current measurement will be equal to the current limit setting. If the current limit setting is incorrect the current calibration must be verified or the control card is faulty. On completion disconnect the dummy load or the discharge battery.

l) Verify the output voltages and record the value. If the measured values are not corresponding to the settings the voltage calibrations must be verified or the control card is faulty.

m) On dual converter systems test the operation of the load transfer switch.

n) Ensure that the converter is in a normal working state, all settings and functions that were changed for test purposes must be returned to normal and all dummy loads must be disconnected.

Note: The following checks and measurements must be done after the loads are made alive.

o) Save the final configuration files to be stored for future reference.

p) Capture all test equipment information.

q) If any changes were affected to the drawings or settings ensure the applicable engineering change process is followed to update the design.

3.5.7 Inverters

For standard check sheet see Annex D

a) At this stage all isolators and MCB's must be in the open position.

b) Once the project schedule has been signed off to this point of commissioning and all cables have been tested and safety clearances issued then the input DC supply can be switched on at the DC supply DB. Measure the polarity and value of the supply voltage and ensure it is within specifications.

c) Each supplier has a unique switching procedure that needs to be followed. Take time between each step to ensure the Inverter behaves as expected and observe all values and alarms.

d) Measure the output voltage for quality.

e) Perform all possible functional checks during SAT.

f) Save all the configuration files.

g) Close output breaker and measure polarity and rotation (3 phase) at the load DB input breaker. If it is correct then close load DB input breaker.

h) If any changes were affected to the drawings or settings ensure the applicable engineering change process is followed to update the design.

3.5.8 Uninterruptable Power Supplies (Simplex and Modular)

For standard check sheet see **Error! Reference source not found.**

Dual redundant UPS are also regarded as single systems since they are not connected at the output but redundancy occurs in the load itself.

3.5.8.1 Single systems

a) At this stage all isolators and MCB's must be in the open position.

b) Once the project schedule has been signed off to this point of commissioning and all cables have been tested and safety clearances issued then the input AC supply can be switched on to the rectifier and by-pass supply, if it is a separate supply.

c) Measure the voltage, frequency and phase rotation of the supplies before anything is switched on to ensure it is within specifications.

d) Connect the battery cables at the battery end but make the battery open circuit by removing one inter-row connector. This will ensure that battery cables are secured and cannot accidentally touch earth or any other live potential or make any short circuits and are exposed in order to take measurements. Not all UPS's have internal or external battery isolators and only have fuses. Some UPS's have battery contactors or solid state switches making it difficult to take polarity measurements between the UPS output and the battery installation. During commissioning it will be essential to confirm battery polarity before closing the supply to the battery.

e) With the UPS on and supplying the load DB access the UPS controller either from the key-pad or via PC connection and ensure that all the settings are as per FAT test sheet and Settings document. Save all the configuration files.

f) All equipment manufacturers have a unique switching procedure that needs to be followed. Take time between each step to ensure the UPS behaves as expected and observe all values and alarms.

g) At some point of any UPS sequence once the Rectifier and/or Buck/Boost charger is switched on and output voltage is supplied to the battery output terminal, then measure the polarity and compare with the polarity from the battery or confirm the polarity at the battery terminals. Measure over any switching device if available. Battery cable polarity check.

h) Once the Inverter is switched on it will synchronise to the by-pass supply and the static switch will transfer the load from by-pass supply to inverter supply. At this point the output breaker will still be open and also the input feeder breaker on the load distribution board. Ensuring the load DB input breaker is open close the UPS output breaker.

i) All phase voltage, polarity and/or sequence checks must be confirmed at the DB UPS 1 input breaker.

j) All output circuits of the load DB must be open.

k) Using the manual, drawings and other means to your disposal simulate different scenarios in order to initiate all individual alarms and test them thru to control. If possible get a printout of the alarms at control and attach it to the commissioning check sheet.

l) Close the input breaker of the DB. Measure the voltages on all bus-bars.

m) On systems fitted with wrap-around facility it is now important to perform the polarity and phase rotation checks of the wrap-around supply. The supply should have a dedicated breaker on the UPS supply DB and an input breaker on the load distribution board. Close the breaker on the supply DB and measure the voltages over each phase on the load DB Wrap-around input breaker making sure the supply is in phase with the bus-bar or output of the UPS.

n) On UPSs fitted with battery isolators or fused switches, close these in order to connect the batteries.

o) On UPS systems fitted with battery fuses only switch off the UPS in order to connect the battery cables and then switch on again according to procedure.

p) On systems designed with auxiliary contacts on the Wrap-around beakers to switch the UPS to by-pass when they operate, test the supply DB and Load DB breakers individually.

q) On the modular UPS used by Eskom as a Dip Proof Inverter Protection section needs to test the operation of the under voltage relay/disturbance recorder. Save all configuration files. Attach results to check sheet.

r) Commission the charger as per clause 3.5.4 or 3.5.5 dependant on type of rectifier

s) Using the manual, drawings and other means to your disposal simulate different scenarios in order to initiate all individual alarms and test them thru to control. If possible get a printout of the alarms at control and attach to the commissioning check sheet

t) Perform all possible functional checks during SAT.

u) If any changes were affected to the drawings or settings ensure the applicable engineering change process is followed to update the design.

3.5.8.2 Dual redundant systems

On this UPS System the two UPSs are connected to a common output.

a) At this stage all isolators and MCB's must be in the open position.

b) On a dual redundant UPS system check the communication cables to be installed correctly between the parallel UPS's.

Note: Perform the following actions c) to i) on both UPS 1&2.

c) Once the project schedule has been signed off to this point of commissioning and all cables have been tested and safety clearances issued then the input AC supply can be switched on to the rectifier and by-pass supply, if it is a separate supply.

d) Measure the voltage, frequency and phase rotation of the supplies before anything is switched on to ensure it is within specifications.

e) Connect the battery cables at the battery end but make the battery open circuit by removing one inter-row connector. This will ensure that battery cables are secured and cannot accidentally touch earth or any other live potential or make any short circuits and are exposed in order to take measurements. Not all UPS's have internal or external battery isolators and only have fuses. Some UPS's have battery contactors or solid state switches making it difficult to take polarity measurements between the UPS output and the battery installation. During commissioning it will be essential to confirm battery polarity before closing the supply to the battery.

f) With the UPSs on access the UPS controller either from the key-pad or via PC connection and ensure that all the settings are as per FAT test sheet and Settings document. Save all the configuration files.

g) All equipment manufacturers have a unique switching procedure that needs to be followed. Take time between each step to ensure the UPS behaves as expected and observe all values and alarms.

h) At some point of any UPS sequence once the Rectifier and/or Buck/Boost charger is switched on and output voltage is supplied to the battery output terminal, then measure the polarity and compare with the polarity from the battery or confirm the polarity at the battery terminals. Measure over any switching device if available. Battery cable polarity check.

i) Once the Inverter is switched on it will synchronise to the by-pass supply and the static switch will transfer the load from by-pass supply to inverter supply. At this point the output breaker will still be open and also the input feeder breaker on the load distribution board. Ensuring the load DB input breaker is open close the UPS output breaker.

j) All phase voltage, polarity and/or sequence checks must be confirmed at the DB UPS 1&2 input breakers.

k) All output circuits of the load DB must be open.

l) Close the UPS 1&2 input breakers of the load DB. Measure the voltages on all bus-bars.

m) On systems fitted with wrap-around facility it is now important to perform the polarity and phase rotation checks of the wrap-around supply. The supply should have a dedicated breaker on the UPS supply DB and an input breaker on the load distribution board. Close the breaker on the supply DB and measure the voltages over each phase on the load DB Wrap-around input breaker making sure the supply is in phase with the bus-bar or output of the UPS.

n) On UPSs fitted with battery isolators or fused switches, close these in order to connect the batteries.

o) On UPS systems fitted with battery fuses only, switch off the UPS in order to connect the battery cables and then switch on again according to procedure.

p) On systems designed with auxiliary contacts on the Wrap-around beakers to switch the UPS to by-pass when they operate, test the supply DB and Load DB breakers individually. Both UPSs must transfer at the same time.

q) Commission the charger as per clause 3.5.4 or 3.5.5 dependant on type of rectifier

r) On the modular UPS used by Eskom as a Dip Proof Inverter, Protection section needs to test the operation of the under voltage relay/disturbance recorder. Save all configuration files. Attach results to check sheet.

s) Using the manual, drawings and other means to your disposal simulate different scenarios in order to initiate all individual alarms and test them thru to control. If possible get a printout of the alarms at control and attach to the commissioning check sheet.

t) Perform all possible functional checks during SAT.

u) If any changes were affected to the drawings or settings ensure the applicable engineering change process is followed to update the design.

3.6 Data Capturing

All the commissioning and equipment information must be captured in the database relevant to the specific line group (Maximo, SAP, etc.).

4. Authorization

This document has been seen and accepted by:

Name and surname	Designation
Deon van Rooi	Metering, DC & Security Technologies Manager
Richard McCurrach	Senior Manager: PTM&C
Kashveer Jagdaw	DC & Auxiliary Supplies SC Chairperson

5. Revisions

Date	Rev	Compiler	Remarks
July 2020	1	Hamus Lourens	New Document

6. Development team

The following people were involved in the development of this document:

- Hamus Lourens (PTM)
- Welman van Niekerk (PTM)

7. Acknowledgements

Not applicable

Annex A – Phase Controlled Battery Chargers Commissioning Check Sheet

INSTALLATION AND COMMISSIONING OF PHASE CONTROL BATTERY CHARGERS	**REFERENCE 240-170000055**

Preliminary information and tasks			
Site Name		Charger Name	
System floating or earthed		If earthed which polarity	
Charger Make		Voltage and Current rating	
Charger Type		Charger Serial Nr.	
Battery make		Battery Type	
Battery Manufacture Date		Nr. of cells	
HIRA no. for this work		Permit nr. if applicable	
Person responsible for commissioning			
Date (Month/Year)			
Contact control on arrival and departure record ref. no. if applicable			
Enter visit in log book and/or complete Workers register			
Save configuration file to laptop and record stored path and file name			

Installation Checks			
	Confirm check done	**Record Value/Condition**	**Comments**
Remove old chargers			
Install new chargers			
Is panel aligned according to other panels and room layout drawing			
Install new AC supply, battery, load, earth and alarm cables.			
Ensure that all cable trenches is properly covered			
Clean inside of equipment cubicle			

Cold Commissioning Checks				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Cable insulation resistance test:				
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Equipment insulation resistance test:				
Input to Earth	>2MΩ			
Output to Earth	>2MΩ			
		Confirm check done	**Record Value/Condition**	**Comments**
Check the following labeling for correctness and in place:				
Name Plate				
Rating Plate				
Fuse and MCB labels				
All Switch gear labels				
All equipment Identification labels				
Cable and terminal numbering				
Standard danger Notices				
Check equipment and sub components secure				
Check wiring termination's secure				
Check components for damage				
Visually inspect earths				
Visually inspect Varistors/Surge protection				
Check MCB and fuse ratings to drawing and label				
If fitted with analogue meters ensure that all are zero				
Hot Commissioning				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure AC supply voltage				
R-N	220V			
W-N	220V			
B-N	220V			
N-E	+/- 0V			
		Confirm check done	**Record Value/Condition**	**Comments**
Record firmware version				
Ensure all settings correspond with attached settings sheet				
Check polarity across all DC isolators/MCB's				

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Measure transformer output voltage				
Primary Bridge R-W	V			
Primary Bridge W-B	V			
Primary Bridge B-R	V			
Delay Bridge R-W	V			
Delay Bridge W-B	V			
Delay Bridge B-R	V			

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Measure AC phases into rectifier bridges				
Primary Bridge R	A			
Primary Bridge W	A			
Primary Bridge B	A			
Delay Bridge R	A			
Delay Bridge W	A			
Delay Bridge B	A			

	Confirm check done	Record Value/Condition	Comments
Measure operation of the SCR's with scope and attach waveform			
Measure positive to earth			
Measure negative to earth			

	Confirm check done	Measured Value	Displayed Value	Comments
Record accuracy of all analogue inputs/feedbacks				

	Ref. Setting	Confirm check done	Operation Value	Comments
Test operation of alarm & protection circuits				
	Ref. Setting	**Confirm check done**	**Operation Value**	**Comments**
Test operation of alarm & protection circuits (continued)				
		Confirm check done	**Record Condition**	**Comments**
Confirm above tested alarms: On display panel				
Confirm above tested alarms: To control				

	Ref. Setting	Confirm check done	Measured Value	Comments
Dropping and blocking\combining diode tests:				
Record Maximum load voltage during functional testing the dropping diodes				
Record Minimum load voltage during functional testing the dropping diodes				
Record volt drop across Dropping Diode stage 1				
Record volt drop across Dropping Diode stage 2				
Record volt drop across Dropping Diode stage 3				
Record volt drop across Dropping Diode stage 4				
Record volt drop across blocking\combining Diode				
	Ref. Setting	**Confirm check done**	**Measured Value**	**Comments**
Measure voltage and current limit settings				
Charger current limit				
Float current limit				
Boost current limit				
Equalize current limit				
Initial current limit				
V float				
V boost				
V equalize				
V initial				
Test load transfer on dual units				

Checks and measurements to be done after loads are liven up.				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure standing load	A			
Measure ripple voltage	mV			
Measure ripple current	A			

Final checks			
Matters recorded on complaints lists yes/no		Ensure that charger is in float mode	
Ensure that the charger is operational		Ensure that the battery isolator is closed	
Ensure that all the initiated alarms has cleared		Ensure that the load isolator is closed	
Save charger event log		Save charger configuration file	
Is database updated			

Type of test equipment	SERIAL NO	CALIBRATION DATE
Oscilloscope		
Multi-Meter		
Current probe		
Power Supply		N/A
Laptop		N/A
REMARKS:		
Checked By Commissioning Technician		
Name (Print)	Signature	Date
Approved By Section/Project/Commissioning Supervisor		
Name (Print)	Signature	Date

Annex B – Switch Mode Battery Chargers Commissioning Check Sheet

INSTALLATION AND COMMISSIONING OF SWITCH MODE BATTERY CHARGERS	**REFERENCE 240-170000055**

Preliminary information and tasks			
Site Name		Charger Name	
System floating or earthed		If earthed which polarity	
Charger Make		Voltage and Current rating	
CSU Type		CSU Serial Nr.	
SMR Type		SMR 1 Serial Nr.	
SMR 2 Serial Nr.		SMR 3 Serial Nr.	
SMR 4 Serial Nr.		SMR 5 Serial Nr.	
SMR 6 Serial Nr.		SMR 7 Serial Nr.	
SMR 8 Serial Nr.		SMR 9 Serial Nr.	
SMR 10 Serial Nr.		SMR 11 Serial Nr.	
Battery make		Battery Type	
Battery Manufacture Date		Nr of cells	
HIRA no. for this work		Permit nr. if applicable	
Person responsible for commissioning			
Date (Month/Year)			
Contact control on arrival and departure record ref. no. if applicable			
Enter visit in log book and/or complete Workers register			
Save configuration file to laptop and record stored path and file name			

Installation Checks			
	Confirm check done	**Record Value/Condition**	**Comments**
Remove old chargers			
Install new chargers			
Is panel aligned according to other panels and room layout drawing			
Install new AC supply, battery, earth and alarm cables.			
Ensure that all cable trenches is properly covered			
Clean inside of equipment cubicle			

Cold Commissioning Checks				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Cable insulation resistance test:				
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Equipment insulation resistance test:				
Input to Earth	>2MΩ			
Output to Earth	>2MΩ			
		Confirm check done	**Record Value/Condition**	**Comments**
Check the following labeling for correctness and in place:				
Name Plate				
Rating Plate				
Fuse and MCB labels				
All Switch gear labels				
All equipment Identification labels				
Cable and terminal numbering				
Standard danger Notices				
Check equipment and sub components secure				
Check wiring termination’s secure				
Check components for damage				
Visually inspect earths				
Visually inspect Varistors/Surge protection				
Check MCB and fuse ratings to drawing and label				
If fitted with analogue meters ensure that all are zero				

Hot Commissioning				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure AC supply voltage				
R-N	220V			
W-N	220V			
B-N	220V			
N-E	+/- 0V			
		Confirm check done	**Record Value/Condition**	**Comments**
Record firmware version				
Record bootloader version				
Ensure all settings correspond with attached settings sheet				
Check polarity across all DC isolators/MCB's				
Measure positive to earth				
Measure negative to earth				
	Confirm check done	**Measured Value**	**Displayed Value**	**Comments**
Record accuracy of all analogue inputs/feedbacks				
	Ref. Setting	**Confirm check done**	**Operation Value**	**Comments**
Test operation of alarm & protection circuits				

		Confirm check done	Record Condition	Comments
Confirm above tested alarms: On display panel				
Confirm above tested alarms: To control				
	Ref. Setting	**Confirm check done**	**Measured Value**	**Comments**
Dropping and blocking\combining diode tests:				
Record Maximum load voltage during functional testing the dropping diodes				
Record Minimum load voltage during functional testing the dropping diodes				
Record volt drop across Dropping Diode stage 1				
Record volt drop across Dropping Diode stage 2				
Record volt drop across Dropping Diode stage 3				
Record volt drop across Dropping Diode stage 4				
Record volt drop across blocking\combining Diode				
Measure voltage and current limit settings				
Charger current limit				
Float current limit				
Boost current limit				
Equalize current limit				
Initial current limit				
V float				
V boost				
V equalize				
V initial				
Test load transfer on dual units				

Checks and measurements to be done after loads are liven up.				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure standing load	A			

Final checks			
Matters recorded on complaints lists yes/no		Ensure that charger is in float mode	
Ensure that the charger is operational		Ensure that the battery isolator is closed	
Ensure that all the initiated alarms has cleared		Ensure that the load isolator is closed	
Save charger event log		Save charger configuration file	
Is database updated			

Type of test equipment	SERIAL NO	CALIBRATION DATE
Oscilloscope		
Multi-Meter		
Current probe		
Power Supply		N/A
Laptop		N/A
REMARKS:		
Checked By Commissioning Technician		
Name (Print)	Signature	Date
Approved By Section/Project/Commissioning Supervisor		
Name (Print)	Signature	Date

Annex C – DC to DC Converters Commissioning Check Sheet

INSTALLATION AND COMMISSIONING OF DC-DC CONVERTER	**REFERENCE 240-170000055**

Preliminary information and tasks			
Site Name		DC-DC Converter Name	
System floating or earthed		If earthed which polarity	
DC-DC Converter Make		Voltage and Current rating	
CSU Type		CSU Serial Nr.	
CONVERTER Type		CONVERTER 1 Serial Nr.	
CONVERTER 2 Serial Nr.		CONVERTER 3 Serial Nr.	
CONVERTER 4 Serial Nr.		CONVERTER 5 Serial Nr.	
CONVERTER 6 Serial Nr.		CONVERTER 7 Serial Nr.	
CONVERTER 8 Serial Nr.		CONVERTER 9 Serial Nr.	
CONVERTER 10 Serial Nr.		CONVERTER 11 Serial Nr.	
HIRA no. for this work		Permit nr. if applicable	
Person responsible for commissioning			
Date (Month/Year)			
Contact control on arrival and departure record ref. no. if applicable			
Enter visit in log book and/or complete Workers register			
Save configuration file to laptop and record stored path and file name			

Installation Checks			
	Confirm check done	**Record Value/Condition**	**Comments**
Remove old DC-DC Converters			
Install new DC-DC Converters			
Is panel aligned according to other panels and room layout drawing			
Install new DC supply, earth and alarm cables.			
Ensure that all cable trenches is properly covered			
Clean inside of equipment cubicle			

Cold Commissioning Checks				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Cable insulation resistance test:				
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Equipment insulation resistance test:				
Input to Earth	>2MΩ			
Output to Earth	>2MΩ			
		Confirm check done	**Record Value/Condition**	**Comments**
Check the following labeling for correctness and in place:				
Name Plate				
Rating Plate				
Fuse and MCB labels				
All Switch gear labels				
All equipment Identification labels				
Cable and terminal numbering				
Standard danger Notices				
Check equipment and sub components secure				
Check wiring termination’s secure				
Check components for damage				
Visually inspect earths				
Visually inspect Varistors/Surge protection				
Check MCB and fuse ratings to drawing and label				
If fitted with analogue meters ensure that all are zero				

Hot Commissioning				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure DC supply voltage				
		Confirm check done	**Record Value/Condition**	**Comments**
Record firmware version				
Record bootloader version				
Ensure all settings correspond with attached settings sheet				
Check polarity across all DC isolators/MCB's				
Measure positive to earth				
Measure negative to earth				
	Confirm check done	**Measured Value**	**Displayed Value**	**Comments**
Record accuracy of all analogue inputs/feedbacks				
	Ref. Setting	**Confirm check done**	**Operation Value**	**Comments**
Test operation of alarm & protection circuits				
		Confirm check done	**Record Condition**	**Comments**
Confirm above tested alarms: On display panel				
Confirm above tested alarms: To control				

	Ref. Setting	Confirm check done	Measured Value	Comments
Record volt drop across blocking\combining Diode				
Measure voltage and current limit settings				
DC-DC Converter current limit				
DC-DC Converter output voltage				
Test load transfer on dual units				

Checks and measurements to be done after loads are liven up.				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure standing load	A			

Final checks			
Matters recorded on complaints lists yes/no		Ensure that the DC-DC Converter is operational	
Ensure that all the initiated alarms has cleared		Ensure that the load isolator is closed	
Save DC-DC Converter event log		Save DC-DC Converter configuration file	
Is database updated			

Type of test equipment	**SERIAL NO**	**CALIBRATION DATE**
Oscilloscope		
Multi-Meter		
Current probe		
Power Supply		N/A
Laptop		N/A

REMARKS:

Checked By Commissioning Technician		
Name (Print)	Signature	Date
Approved By Section/Project/Commissioning Supervisor		
Name (Print)	Signature	Date

Annex D – Inverters Commissioning Check Sheet

INSTALLATION AND COMMISSIONING OF INVERTER		**REFERENCE 240-170000055**	
Preliminary information and tasks			
Site Name		Inverter Name	
Inverter Make		Voltage and Current rating	
Inverter Type		Inverter Serial Nr.	
HIRA no. for this work		Permit nr. if applicable	
Person responsible for commissioning			
Date (Month/Year)			
Contact control on arrival and departure record ref. no. if applicable			
Enter visit in log book and/or complete Workers register			
Save configuration file to laptop and record stored path and file name			

Installation Checks			
	Confirm check done	**Record Value/Condition**	**Comments**
Remove old Inverter			
Install new Inverter			
Is panel aligned according to other panels and room layout drawing			
Install new DC supply, Bypass AC supply, Inverter output, earth and alarm cables.			
Ensure that all cable trenches is properly covered			
Clean inside of equipment cubicle			

Cold Commissioning Checks				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Cable insulation resistance test:				
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Equipment insulation resistance test:				
Inverter Input to Earth	>2MΩ			
Bypass Input to Earth	>2MΩ			
Inverter Output to Earth	>2MΩ			
		Confirm check done	Record Value/Condition	Comments
Check the following labelling for correctness and in place:				
Name Plate				
Rating Plate				
Fuse and MCB labels				
All Switch gear labels				
All equipment Identification labels				
Cable and terminal numbering				
Standard danger Notices				
Check equipment and sub components secure				
Check wiring termination's secure				
Check components for damage				
Visually inspect earths				
Visually inspect Varistors/Surge protection				
Check MCB and fuse ratings to drawing and label				
If fitted with analogue meters ensure that all are zero				
Ensure communication cable is installed between dual Inverter's				
Hot Commissioning				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure DC supply voltage	V			
Measure Bypass AC supply voltage				
R-N	220V			
W-N	220V			
B-N	220V			
N-E	+/- 0V			
Measure Bypass AC supply Frequency	50HZ			
Ensure Bypass AC Phase rotation is correct	R-W-B			

		Confirm check done	Record Value/Condition	Comments
Record firmware version				
Ensure all settings correspond with attached settings sheet				
Check polarity across all DC isolators/MCB's/fuses				
Use the Manufacturers procedure and test the following:				
Inverter start-up switching procedure				
Inverter transfer to manual bypass procedure				
Inverter transfer from manual bypass back to inverter procedure				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure Inverter output voltage				
R-N	220V			
W-N	220V			
B-N	220V			
N-E	+/- 0V			
Measure Inverter output Frequency	50HZ			
Ensure Inverter output Phase rotation is correct up to DB input	R-W-B			
		Confirm check done	**Record Value/Condition**	**Comments**
If applicable Test phasing across wrap around isolator				
If applicable Test Inverter wrap-around function				
Ensure testing of under voltage relay/disturbance recorder (DPI Inverter only)				
	Confirm check done	**Measured Value**	**Displayed Value**	**Comments**
Record accuracy of all analogue inputs/feedbacks				

	Ref. Setting	Confirm check done	Operation Value	Comments
Test operation of alarm & protection circuits				

	Confirm check done	Record Condition	Comments
Confirm above tested alarms: On display panel			
Confirm above tested alarms: To control			

Checks and measurements to be done after loads are liven up.				
	Ref. Value	**Confirm check done**	**Record Value**	**Comments**
Measure Inverter standing load	A			
Measure ripple voltage	mV			
Measure ripple current	A			

Final checks			
Matters recorded on complaints lists yes/no		Ensure that Inverter is in float mode	
Ensure that the Inverter is operational		Ensure that the battery isolator is closed	
Ensure that all the initiated alarms has cleared		Ensure that the load isolator is closed	
Save Inverter event log		Save Inverter configuration file	
Is database updated			

Type of test equipment	**SERIAL NO**	**CALIBRATION DATE**
Oscilloscope		
Multi-Meter		
Current probe		
Power Supply		N/A
Laptop		N/A

REMARKS:		
Checked By Commissioning Technician		
Name (Print)	Signature	Date
Approved By Section/Project/Commissioning Supervisor		
Name (Print)	Signature	Date

Annex E – Uninterruptable Power Supplies Commissioning Check Sheet

INSTALLATION AND COMMISSIONING OF UNINTERRUPTIBLE POWER SUPPLIES	**REFERENCE 240-170000055**

Preliminary information and tasks			
Site Name		UPS Name	
UPS Make		Voltage and Current rating	
UPS Type		UPS Serial Nr.	
Battery make		Battery Type	
Battery Manufacture Date		Nr. of cells	
HIRA no. for this work		Permit nr. if applicable	
Person responsible for commissioning			
Date (Month/Year)			
Contact control on arrival and departure record ref. no. if applicable			
Enter visit in log book and/or complete Workers register			
Save configuration file to laptop and record stored path and file name			

Installation Checks			
	Confirm check done	**Record Value/Condition**	**Comments**
Remove old UPS			
Install new UPS			
Is panel aligned according to other panels and room layout drawing			
Install new Rectifier AC supply,Bypass AC supply, battery, UPS output, earth and alarm cables.			
Ensure that all cable trenches is properly covered			
Clean inside of equipment cubicle			

Cold Commissioning Checks				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Cable insulation resistance test:				
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			
	>2MΩ			

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Equipment insulation resistance test:				
Rectifier Input to Earth	>2MΩ			
Bypass Input to Earth	>2MΩ			
Rectifier Output to Earth	>2MΩ			
UPS Output to Earth	>2MΩ			

	Confirm check done	Record Value/Condition	Comments
Check the following labelling for correctness and in place:			
Name Plate			
Rating Plate			
Fuse and MCB labels			
All Switch gear labels			
All equipment Identification labels			
Cable and terminal numbering			
Standard danger Notices			
Check equipment and sub components secure			
Check wiring termination's secure			
Check components for damage			
Visually inspect earths			
Visually inspect Varistors/Surge protection			
Check MCB and fuse ratings to drawing and label			
If fitted with analogue meters ensure that all are zero			
Ensure communication cable is installed between dual UPS's			

Hot Commissioning

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Measure Rectifier AC supply voltage				
R-N	220V			
W-N	220V			
B-N	220V			
N-E	+/- 0V			
Measure Rectifier AC supply Frequency	50HZ			
Ensure Rectifier AC supply Phase rotation is correct	R-W-B			

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Measure Bypass AC supply voltage				
R-N	220V			
W-N	220V			
B-N	220V			
N-E	+/- 0V			
Measure Bypass AC supply Frequency	50HZ			
Ensure Bypass AC Phase rotation is correct	R-W-B			
		Confirm check done	**Record Value/Condition**	**Comments**
Record firmware version				
Ensure all settings correspond with attached settings sheet				
Check polarity across all DC isolators/MCB's/fuses				
		Confirm check done	**Record Value/Condition**	**Comments**
Use the Manufacturers procedure and test the following:				
UPS start-up switching procedure				
UPS transfer to manual bypass procedure				
UPS transfer from manual bypass back to inverter procedure				
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure UPS output voltage				
R-N	220V			
W-N	220V			
B-N	220V			
N-E	+/- 0V			
Measure UPS output Frequency	50HZ			
Ensure UPS output Phase rotation is correct up to DB input	R-W-B			
		Confirm check done	**Record Value/Condition**	**Comments**
If applicable Test phasing across wrap around isolator				
If applicable Test UPS wrap-around function				
Ensure testing of under voltage relay/disturbance recorder (DPI UPS only)				

	Ref. Value	Confirm check done	Record Value/Condition	Comments
Measure rectifier transformer output voltage				
Primary Bridge R-W	V			
Primary Bridge W-B	V			
Primary Bridge B-R	V			
Delay Bridge R-W	V			
Delay Bridge W-B	V			
Delay Bridge B-R	V			
	Ref. Value	**Confirm check done**	**Record Value/Condition**	**Comments**
Measure AC phases current into rectifier bridges				
Primary Bridge R	A			
Primary Bridge W	A			
Primary Bridge B	A			
Delay Bridge R	A			
Delay Bridge W	A			
Delay Bridge B	A			
		Confirm check done	**Record Value/Condition**	**Comments**
Measure operation of the SCR's with scope and attach waveform				
	Confirm check done	**Measured Value**	**Displayed Value**	**Comments**
Record accuracy of all analogue inputs/feedbacks				

	Ref. Setting	Confirm check done	Operation Value	Comments
Test operation of alarm & protection circuits				
	Ref. Setting	Confirm check done	Operation Value	Comments
Test operation of alarm & protection circuits (continued)				

		Confirm check done	Record Condition	Comments
Confirm above tested alarms: On display panel				
Confirm above tested alarms: To control				
	Ref. Setting	**Confirm check done**	**Measured Value**	**Comments**
Measure voltage and current limit settings				
Charger current limit				
Float current limit				
Boost current limit				
Equalize current limit				
Initial current limit				
V float				
V boost				
V equalize				
V initial				

Checks and measurements to be done after loads are liven up.				
	Ref. Value	**Confirm check done**	**Record Value**	**Comments**
Measure UPS standing load	A			
Measure ripple voltage	mV			
Measure ripple current	A			

Final checks			
Matters recorded on complaints lists yes/no		Ensure that UPS is in float mode	
Ensure that the UPS is operational		Ensure that the battery isolator is closed	
Ensure that all the initiated alarms has cleared		Ensure that the load isolator is closed	
Save UPS event log		Save UPS configuration file	
Is database updated			

Type of test equipment	**SERIAL NO**	**CALIBRATION DATE**
Oscilloscope		
Multi-Meter		
Current probe		
Power Supply		N/A
Laptop		N/A

REMARKS:		
Checked By Commissioning Technician		
Name (Print)	Signature	Date
Approved By Section/Project/Commissioning Supervisor		
Name (Print)	Signature	Date