

SECTION-C

Tender No. IPR/TN/PUR/TPT/ET/18-19/48 Dated 09-01-2019

TECHNICAL SPECIFICATION

FOR

**100 kV DC, 10 mA, 1 kW OIL COOLED
RESISTIVE LOAD BANK MODULES**



INSTITUTE FOR PLASMA RESEARCH

BHAT, GANDHINAGAR – 382 428

GUJARAT, INDIA

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1. SCOPE OF SUPPLY:

The scope of supply as defined in this tender document including annexures covers Design, Engineering, Assembly, Factory Acceptance Testing, and Supply, Installation and Site Acceptance Testing of *50 (fifty) units of 100 kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank Modules along with accessories and essential spares* at Institute for Plasma Research (IPR), Gandhinagar as per the detailed technical specification mentioned in this tender document.

2. SCOPE OF WORK

The scope of work includes, but not limited to, the following main tasks:

- a) Design of 50 nos. of 100 kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank Modules as per technical specifications specified in Section-4.
- b) Submission of detailed engineering design report/documents, drawings, quality plan and manufacturing schedule, FAT & SAT procedures for IPR's review and approval.
- c) Procurement of electrical components viz. Non inductive Resistors, Anti corona ring assembly, End Terminations including Clamps & Connectors, Polypropylene Fiberglass Tube with fittings & accessories etc. as per technical specifications and as may be required for complete design and development of Resistive Load Bank modules.
- d) Assembly of Resistive Load Bank modules
- e) Arrange the stage wise inspections as per agreed Quality Plan and implementation of modifications (if any).
- f) Perform the Factory Acceptance Tests (FAT) as per approved acceptance test procedure complying the specifications as specified in Section-6.2.
- g) Upon receipt of dispatch clearance note from IPR, Pack and Deliver the Load Bank modules at IPR site as per Section-8. Including supply of essential spares of all type as per technical specifications.
- h) Installation and assembly of 50 nos. of 100 kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank modules (Refer Section-7).
- i) Perform the Site Acceptance Tests (SAT) of individual module as per Section-6.3.
- j) Provide operational and instruction manuals with full technical details. (Refer Section-8.5.)
- k) Provide FAT and SAT reports with all tests results, to the IPR before final acceptance.
- l) Provide technical support as per warranty clause.

3. APPLICATION DESCRIPTION

A regulated 500 kV, 100 mA DC Power Supply system is being developed at IPR. This power supply system primarily comprises of a High Frequency Power Supply (HFPS) unit, high voltage (HV) step up transformer, and a symmetrical Cockcroft-Walton voltage multiplier (CW-Multiplier) unit. The 500 kV, 100 mA DC power supply shall supply high voltage power to a particle accelerator OR used to test the high voltage component for its insulation/dielectric strength. A simplified block diagram showing the scheme of 500 kV, 100 mA DC Power Supply system is shown in Figure-1.

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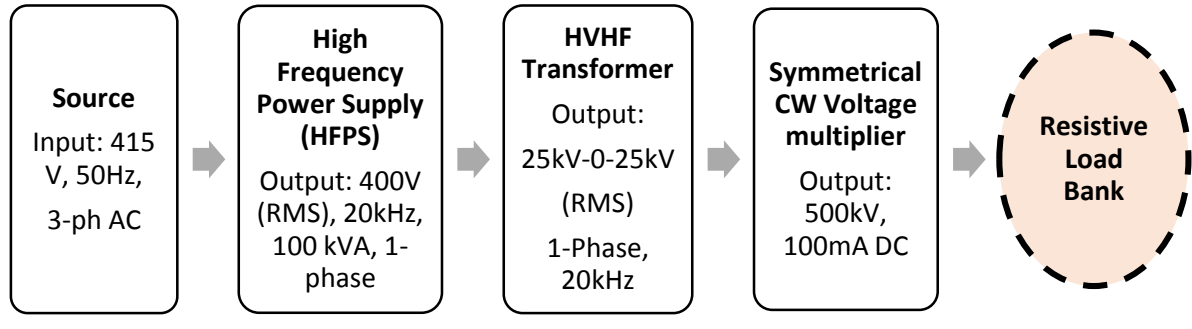


Figure 1: General Block Diagram of 500 kV, 100 mA DC Power Supply

To fully test and characterize 500 kV, 100 mA DC Power Supply system the Load Bank is required. This load bank shall be built by assembling required numbers of load bank modules, in series and parallel combinations.

4. TECHNICAL SPECIFICATIONS

The 50 nos. of 100 kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank module shall be designed and manufactured/assembled as per technical specification defined in Table-1.

Table 1: Technical Specification of 500kV Resistive Load Bank Module

Sr. No.	PARAMETERS	IPR REQUIREMENT
1.	Site Condition:	
a)	Ambient Temperature (maximum/minimum/average (annual))	47 °C / 4 °C / 35 °C
b)	Relative Humidity (maximum / minimum)	90 % / 17 %
c)	Altitude	55 meters above MSL
d)	Installation	Indoor
2.	Load Bank Specifications:	
a)	Application	To Test and Characterize HV DC Power Supply at different voltage and current ratings
b)	Constructional	Modular for ease of obtaining the required voltage and current rating.
c)	Rated Voltage	100 kV DC.
d)	Rated Current	10 mA
e)	Rated Power	1 kW
f)	DC isolation from the HV terminal to grounded point	120 kV DC
g)	Operating duty cycle	30 Minutes ON / 90 Minutes OFF.
h)	Resistance Value	10MΩ to draw 10 mA at 100 kV DC (Single Module)
i)	Temperature coefficient	Less than 500 ppm/ °C
j)	Tolerance	± 5% or less

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k)	Type of Resistor	Non inductive metal film Resistors with metallic caps on the ends suitable for oil immersed operation.
l)	Cooling	Oil natural air natural
m)	Insulating medium	EHV grade Mineral oil
n)	HV Tank Enclosure material	Polypropylene Fiberglass Tank
o)	HV Termination	Through anti corona ring with metal links for different current selection (off load type).
p)	Configuration	The basic module shall have the provision (off load type) for connecting in series and parallel combination of various modules for different voltage/current selection.
q)	Overall dimensions of 100 kV DC /10 mA single module	≤ 900 mm height ≤ 400 mm diameter OR ≤ 100 liters volume
r)	Quantity	50 nos.
s)	Accessories	a) Earthing rod- FRP rod with brass spade end and suitable length (5 meter) of flexible cable b) Trolley (10 Nos.) having bi directional wheels with suitable locking mechanism to mount 5 stacks of basic module. c) Metal Links/HV capsule for connecting various 500kV DC, 10mA Legs. d) Corona balls of suitable diameter (10 Nos.) with a provisions to fix at top anti-corona flange of each 500kV DC, 10mA legs.
t)	Applicable Standards	IEC 60060-1:2010 (Edition 3.0 2010-9) / IEC 60060-2:2010 (Edition 3.0 2010-11) and as applicable

5. TECHNICAL REQUIREMENTS

5.1. Construction details of module:

- a) Bidder shall design basic modules (100kV DC, 10mA, 1kW) in such a way that each modules are interchangeable and can be placed in any position.
- b) The resistive elements of a single module shall be mounted on polycarbonate sheet or suitable insulating material with supporting insulators. The inter stage electrical connections between sub modules shall be made with the help of connector/conductive link for a trouble free connectivity and for the ease in the assembly of the vertical stacking.
- c) The HV enclosure of basic modules shall be made from Polypropylene Fiberglass material.
- d) The size of the tank shall be designed to enclose and hold the entire resistor assembly of the basic load bank module with appropriate clearance/spacing as required between

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the live and ground part and facilitate natural conductive/convective heat dissipation to air.

- e) The end terminals from each basic module shall be brought out from the tank through aluminum anti-corona flanges of suitable diameter.
- f) Top and bottom anti corona flanges of basic modules of Load Bank shall be adequately fixed with body of tank/fiberglass HV tube through a threaded mechanism to seal the modules in order to make it leak proof.
- g) Top anti-corona flanges of basic modules of Load Bank shall be provided with a detachable cover with an O-Ring to remove entire resistor assembly when maintenance required.
- h) The body of the tank shall be thoroughly cleaned and should have a smooth surface. The body shall be painted with a poly-urethane (PU) anti tracking coat.
- i) Terminal marking, rating name plate, danger sign and general HV Load Bank design scheme display shall be fitted on to tank body.
- j) The HV tank shall be filled with EHV grade Mineral Oil.
- k) Higher voltage rating shall be achieved by having multiple modules stacked in series on top of one another.
- l) Anti-corona flanges at the top/bottom of each module shall have the provision for stacking several modules one over the other and should have smooth surface finish while stacking one above the other without any chance to create voids between them.
- m) Bidder shall design the anti-corona flange with a provision to connect corona balls of suitable diameter on top of each module.
- n) Bidder shall ensure corona free operation of region where nuts and bolts used to stack individual modules. The nuts and bolts should be of suitable size and shape.
- o) The load bank shall be provided with safe and secured grounding arrangement firmly connected to the base/trolley of HV load bank.
- p) Bidder shall ensure the assembly without any sharp metallic points or any sharp soldering joints or welding joints.
- q) The indicative / reference design of 100 kV DC / 10 mA single module and assembly drawings of 500 kV, 100 mA DC Load Bank with major ratings of the components are provided in Annexure I. Changes in this indicative / reference design and drawings may be possible based on bidder engineering development skills and availability of the required components in the market.

5.2. Selection of HV Resistors

- a) Resistor element used for constructing HV DC Load Bank shall be of non-inductive metal film type suitable for high voltage applications.
- b) Resistor element selected for series string of a basic module should have enough wattage rating considering the de-rating factor with increase in operating temperature and voltage capability.
- c) Resistor element shall be physically arranged and mounted in such a way as to avoid any path for voltage break down while also allowing for the proper dissipation of heat.
- d) Coating on the resistor element must be compatible to high temperature and oil immersion.

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- e) Resistor elements must be provided with smooth metallic caps/rings to avoid corona discharges.
- f) The total inductance per 100 kV DC/ 10 mA module owing to individual resistor element series connection shall be $\leq 2\mu\text{H}$.

5.3. Spares

Following items shall be supplied as spares –

5.3.1 Essential Spares

- a) Resistors of all type and ratings – equivalent to total no. of resistors used for 2 Nos. of 100 kV DC, 10 mA, 1 kW Modules.
- b) Gaskets/O-rings – 5 sets as utilized in each module

5.3.2 Optional Spares

- a) Polypropylene Fiberglass Tank – 2 Nos.
- b) Top and bottom Aluminum anti-corona flange- 4 Nos.
- c) Polycarbonate disc- 4 Nos.
- d) Support insulators- 8 Nos.

5.4. List of Approved makes

S. No.	Description	Make
1.	HV Resistor	Nicrom / Ohmite / Vishay / Metallux/ Kanthal/ Genvolt/ TT Electronics/ Caddock/ HVR/SML Resistors/EBX

6. ACCEPTANCE TESTING

6.1. Factory Acceptance Tests:

Each load Bank module shall be subjected to shop/factory acceptance test (FAT). All the tests shall be carried out at factory in the presence of IPR's representatives. The bidder shall have to prepare test reports and submit to IPR for his approval and acceptance after completion of tests. The tests result of any component or assembly if found unsatisfactory to the purchaser; the same shall be properly rectified and tested again to the satisfaction of the purchaser by the bidder at no extra cost.

6.1.1 Routine Tests

Following routine tests to be performed by the bidder on all 100kV DC modules unless otherwise specified:

- a) Visual & dimensional checks of assembled Modules (50 Nos.).
- a) Resistance measurement (cold) of resistor elements (20% of total quantity selected as samples)
- b) Leakage current measurement through surface of Polypropylene Fiberglass Tank by applying 100kV DC when resistors are not assembled on one sample module only.
- c) Review of test certificates for bought-out items including oil test certificate.
- b) Resistance measurement (cold) on each module

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- c) DC Voltage withstand test at 120 kV for 1minute on each module, voltage applied across end flanges.
- d) Load test on each 100 kV, 10 mA, 1 kW DC Load Bank Module for duty cycle test (30 Minutes ON/90 Minutes OFF) to be repeated till thermalisation.

6.1.2 Type Tests

The Type test mentioned below shall be performed either at bidder's factory (in case the facility exists within the factory OR at external government approved laboratory viz., CPRI, ERDA etc.)

- a) DC High voltage withstand test at 600kV for a duration of 1 minute shall be carried out on a stack of 5 modules connected in series to form one 500 kV DC, 10 mA leg.

6.2. Site Acceptance Tests:

The Load Bank modules shall be subjected to site acceptance tests (SAT) at Purchaser's site by the bidder after completion of the installation work with an advance notice to the IPR. All the tests shall be carried out at site in the presence of IPR representatives. The bidder shall have to prepare test report and submit to IPR for his approval and acceptance after completion of tests. The tests result of any component and assembly if found unsatisfactory to the IPR; the same shall be properly rectified and tested again to the satisfaction of the Purchaser by the Bidder at no extra cost.

Site Acceptance Tests (SAT) are listed as follow,

- a) Visual inspection of the 100 kV DC, 10 mA, 1 kW Load Bank Modules (50 Nos.).
- b) Resistance Measurement test at each individual module.
- c) DC voltage withstand test at 120 kV on each module. Source to be arranged by IPR.

After the completion of SAT, the detailed test report including the test results shall be prepared by the supplier. The representative IPR and Supplier shall jointly sign the SAT test reports.

7. ASSEMBLY

- a) Bidder shall assemble stack of 5 modules in series to form one leg to achieve average power dissipation of 5 kW at 500 kV DC.
- b) Stack of 5 modules shall be mounted on a base/trolley. The trolley should have 360 ° rotation wheels with locking arrangement to move from one place to another.
- r) Bidder shall provide corona balls on top of each leg of 500 kV DC Load bank for tapping and provisions to interconnect each legs with the help of suitable cable / HV Tube with metal legs at each end. Bidder shall design the anti-corona flange with a provision to connect corona balls of suitable diameter on top of each module.
- c) The load bank Trolley (10 Nos.) shall have enough mechanical strength to withstand the weight of the load bank components i.e. stacks of 5 (five) oil filled basic modules and its accessories. Each trolley shall have suitable provision like de-mountable handle for its movement and suitable chain block / link for locking all the 10 trolleys.
- d) The stack of 5 modules shall be provided with safe and secured grounding arrangement firmly connected to the base/trolley of load bank.

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- e) Bidder shall assemble 10 such legs in parallel to achieve average power dissipation of 50 kW at 500 kV DC.
- f) Bidder shall provide anti corona rings at the output terminal of complete assembly.
- g) Bidder shall provide metal links/HV tube/ HV Capsule for the parallel connection of 10 such legs.

8. CONTRACT MANAGEMENT

8.1. Contract Execution Schedule:

The required delivery schedule for all the deliverables is on or before 8 months from the date of approval of the design and drawings submitted by the bidder after the award of contract. A preliminary contract execution schedule which meets the overall delivery duration with major activities and milestones shall be submitted along with the bid. However, the bidder should submit a detailed project execution schedule which meets the targeted delivery time after award of contract. **This project execution schedule include: design, component procurements, manufacturing, FAT, delivery milestone, installation and SAT etc.**

8.2. Quality Assurance Plan (QAP):

The 500kV, 100 mA, 50kW DC Oil Cooled Resistive Load Bank modules shall be manufactured in conformance with the international and/or national standards/codes to assure the quality and reliability of the entire unit. Bidder shall prepare a QAP or a manufacturing inspection plan which ensures the operational quality of the deliverables items under this contract. The same shall be submitted to IPR of its review and approval. QAP shall provide details of inspections/tests that will be carried out at various stages of the contract like design, engineering, procurements, manufacturing, assembly and testing.

8.3. Design and Drawing Submission:

After the award of purchase order / contract, supplier should submit within 30 days the design and drawing of 100 kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank modules and the assembly drawings for 50 such modules in configuration suitable for achieving 500 kV DC, 100 mA, 50 kW load based on the technical proposal submitted during the bid for IPR approval. The submission shall include all but not limited to following documents

-

- a) Design reports/calculations including electrical, thermal and mechanical design of 100 kV DC / 10 mA module. The report shall provide the basis of selection / sizing of all the major components of the assembly with necessary datasheets.
- b) Electrical schematic drawings of HV Load Bank modules.
- c) The detailed fabrication procedure and drawings of tank which shall include all the manufacturing details and tolerances.
- d) Manufacturing and assembly drawings of HV Load Bank modules
- e) List of all accessories, hardware and bill of materials.
- f) Detail data sheets of all HV resistors selected for design and development of HV Load Bank shall be provided.

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8.4. Factory Acceptance Tests (FAT):

FAT shall be performed by the supplier to demonstrate the compliance to contract technical specifications before effecting the shipment, as per Section-6.1. & Section-6.2.

8.5. Operating and Instruction Manual:

The supplier shall submit document / technical literature in form of hard copy and soft copy with complete layout, GA Drawings, detailed block diagrams and circuit diagrams of its assembly with test voltages at different test points of the unit. All aspects of installation, operation, maintenance and troubleshooting instructions as specified below shall be covered in this manual.

- a) Safety measures to be observed in handling of the equipment.
- b) Illustration of internal and external mechanical parts.
- c) Precautions at the time of installation, operation and maintenance.
- d) Procedures for trouble shooting, replacement and routine/preventive maintenance.
- e) Steps of remedial measures for troubleshooting the faults.
- f) Required Test Jigs and fixtures.
- g) Test instruments, test fixtures, accessories and tools required for maintenance and repair.
- h) List of replaceable parts used with the sources of procurement.
- i) A table giving details of sizes and dimensions of cable used
- j) Remedial steps for typical faults.

8.6. Material Dispatch/Packing and Delivery:

After the review and approval of FAT report, a Dispatch Clearance Note shall be issued to supplier by IPR. All the deliverables (hardware and documents) shall be dispatched only after receiving a dispatch clearance note from IPR. However, a mere clearance issued by IPR will not relieve the supplier from the liability of proper functioning of 100kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank modules at IPR Laboratory.

Appropriate safe packing, transportation (including Insurance) to IPR site are under the scope of the supplier, which shall include (but not limited to) a necessary list of documentation and appropriate packing, markings, labelling for the deliverables items. It must be noted that IPR shall not be liable for any of the damages cause during transit of the deliverables. The detailed packaging and transportation scheme shall be submitted to IPR well in advance.

8.7. Site Description:

The laboratory/delivery site is located in the **Institute for Plasma Research Campus, Near Indira Bridge, Bhat, Gandhinagar – 382 428, Gujarat, India**. The laboratory, where 100kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank modules is to be installed is situated at ground floor level in IPR New Auxiliary Building.

8.8. Unloading and Storage:

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Bidder is responsible for unloading of Resistive Load Bank modules and accessories at proper locations at the site and verification of unit for damages and short supplies, making good all such damages and short supplies. The Resistive Load Bank modules and accessories shall be stored at Bidder's responsibility until final acceptance and taking over by IPR.

8.9. Installation:

Bidder is responsible for installation and assembly of 50 modules of 100 kV DC, 10 mA rated including series parallel connection to demonstrate the total rating of 500 kV DC, 100 mA, 50 kW Oil Cooled Resistive Load Bank. Any material or accessory which may not have been specifically mentioned but which is necessary shall be supplied at no extra cost to IPR. ***The installation must complete within 15 days after the material is delivered at site.***

8.10. Site Acceptance Tests (SAT):

SAT shall be performed by the supplier to demonstrate compliance of contract technical specifications after effecting the installation, as per Section-6.2. ***The SAT must complete within 15 days after the material is installed at site.***

8.11. Final Acceptance:

A final acceptance note shall be issued by IPR to the supplier after successful completion of SAT (and after resolving issues completely, if any) at site and submission of "As-built" marked-up drawings incorporating all modifications/changes made during manufacturing, testing and installation of 50 modules of 100kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank modules. The date of issuance of final acceptance note shall be considered as the date of final acceptance.

8.12. Warranty:

Supplier should provide a minimum of one year standard warranty for all the deliverables i.e. 50 modules of 100kV DC, 10 mA, 1 kW Oil Cooled Resistive Load Bank modules and all its accessories thereof from the date of final acceptance issued by IPR. **Additionally, an optional one year extended warranty from the date of expiry of above specified minimum warranty is to be quoted separately.**

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Annexure - I 100 kV DC 10 mA 1kW LOAD BANK REFERENCE DESIGN DRAWINGS

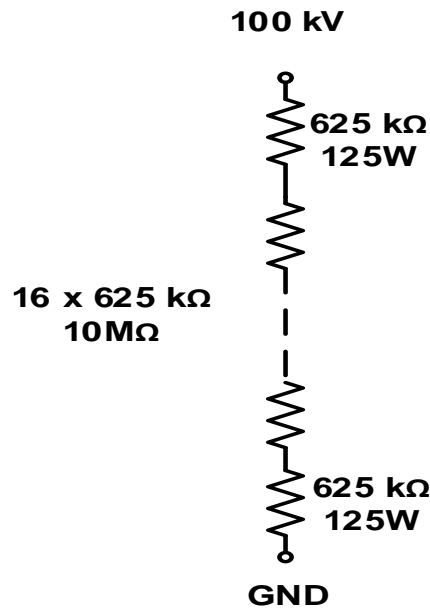


Figure 1: Circuit Diagram of 100 kV DC, 10 mA, 1 kW Basic Module

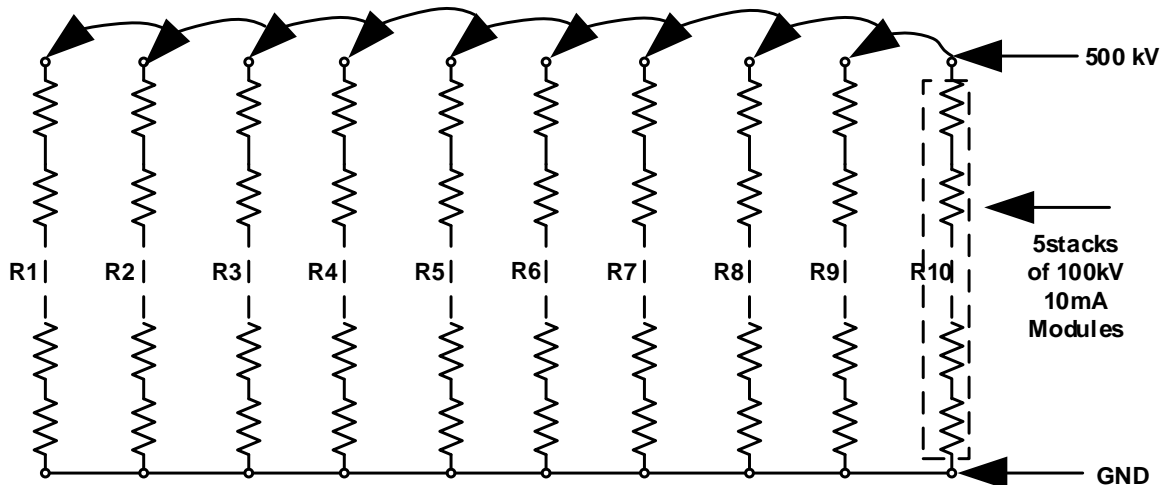


Figure 2: Circuit Diagram of 500 kV DC, 100 mA, 50 kW Load Bank with 10 Legs (5 stacks of Basic Module) in parallel

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NOTE:

THE CALCULATIONS, DESIGN, ELECTRICAL SCHEMATIC AND ASSEMBLY DRAWINGS PROVIDED HERE TO BE CONSIDERED FOR REFERENCE ONLY. BIDDER MAY PROPOSE / SUBMIT HIS OWN DESIGN AND DRAWINGS BASED ON ITS EXPERIENCE AND MANUFACTURING FEASIBILITY ALONG WITH THE BID FOR EVALUATION.

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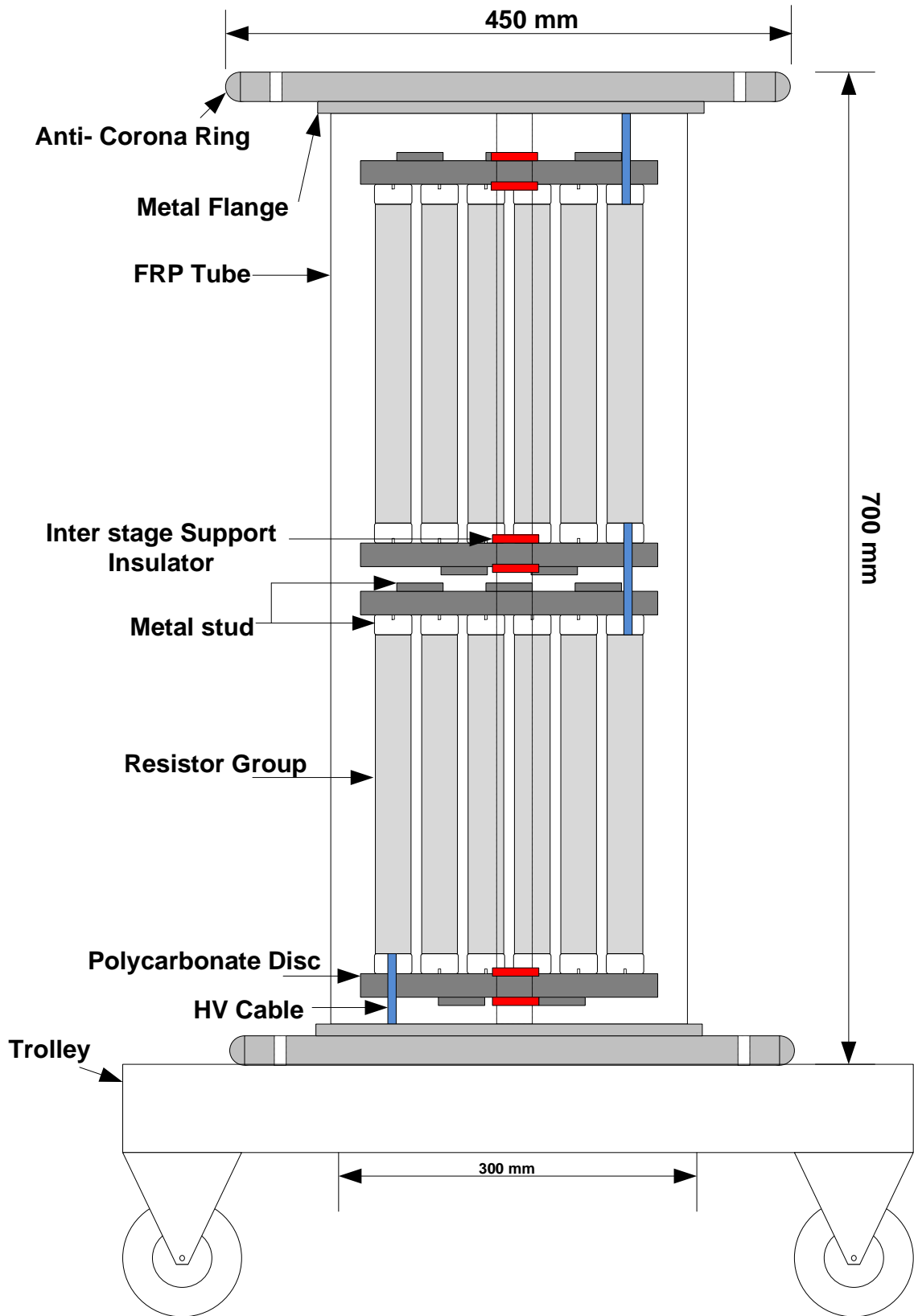


Figure 3: Sectional view of 100kV DC, 10mA 1kW Basic Module

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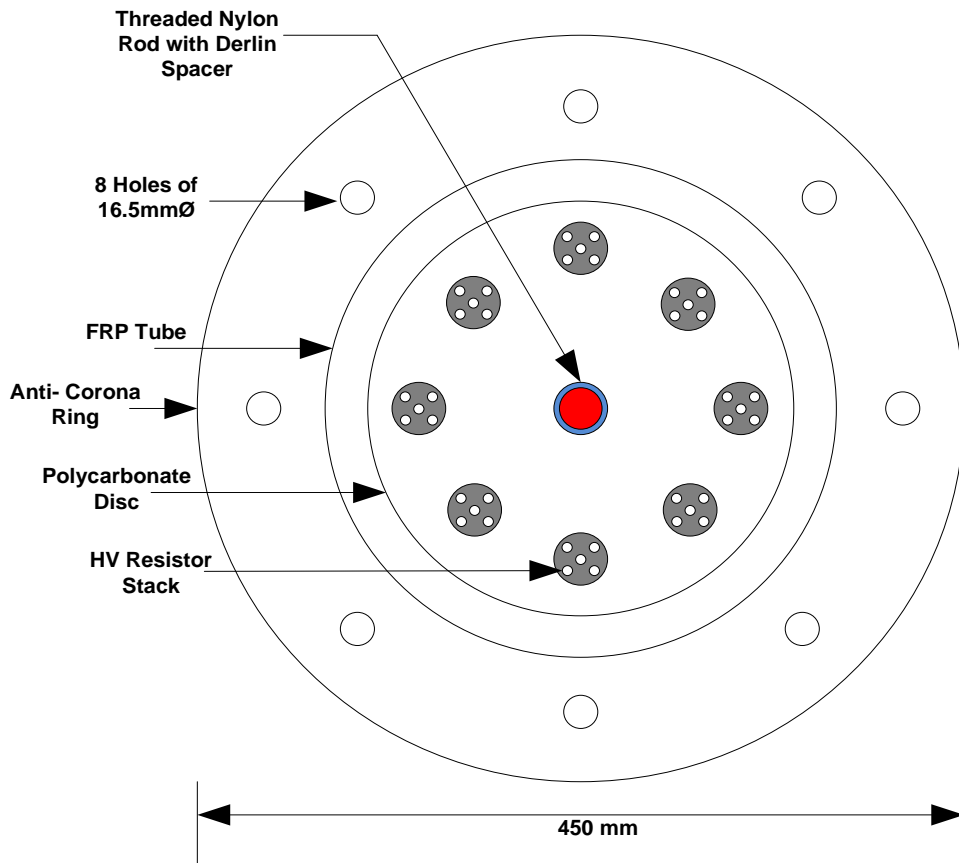
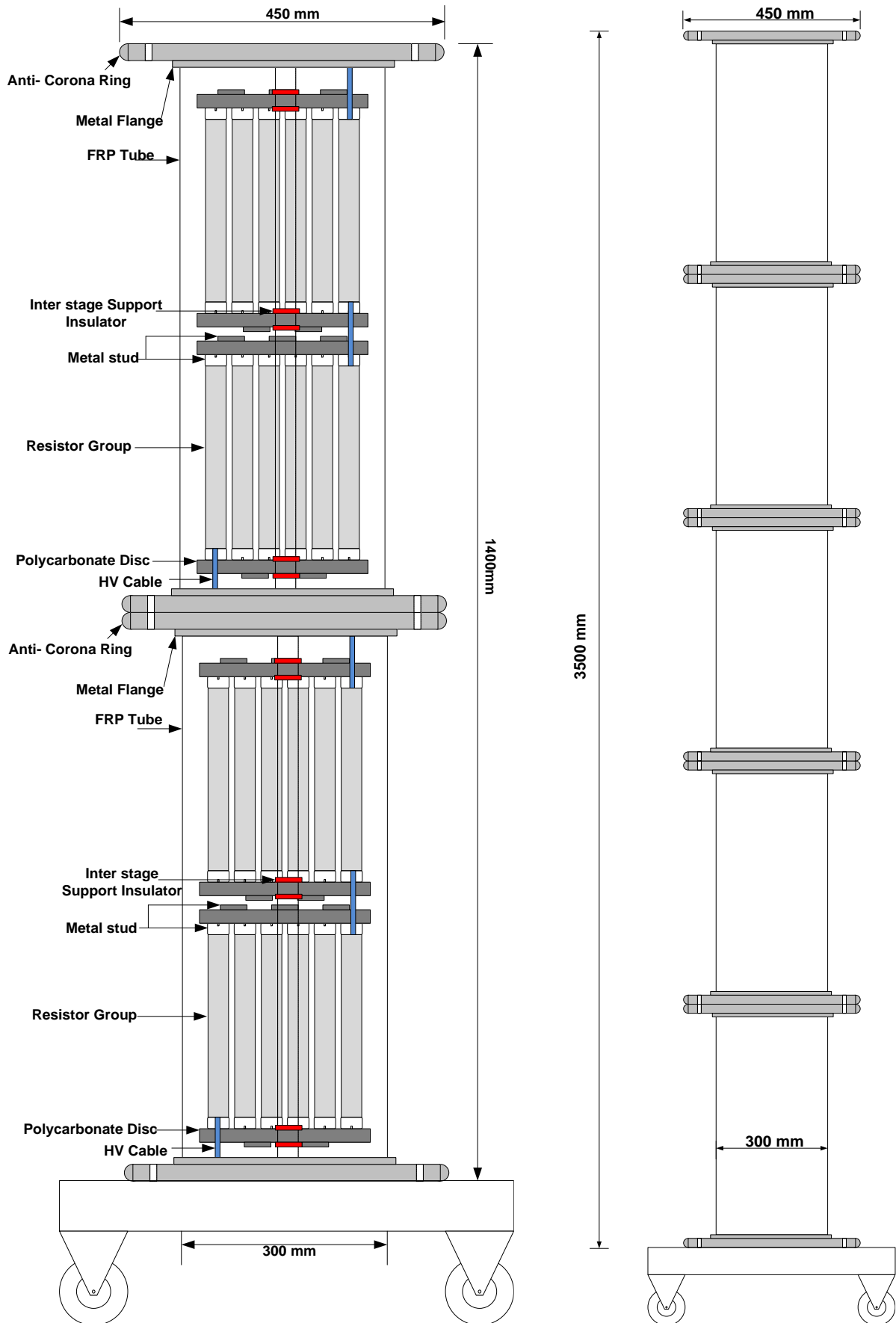


Figure 4: Plan view of 100kV DC, 10mA, 1kW Basic Module

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Figure 5: Cross sectional view of stacking of two and five Basic Modules

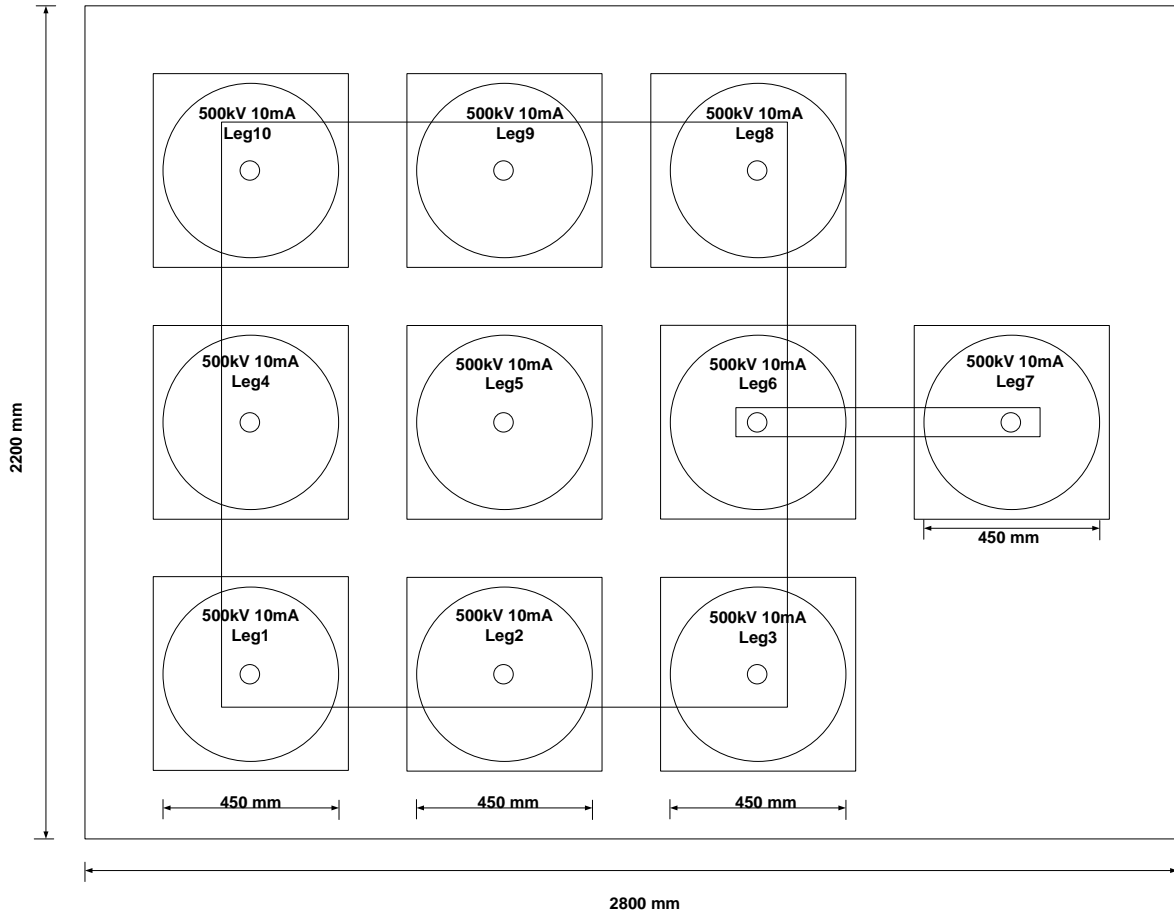


Figure 6: Plan view of 500kV DC, 100mA HV Load Bank

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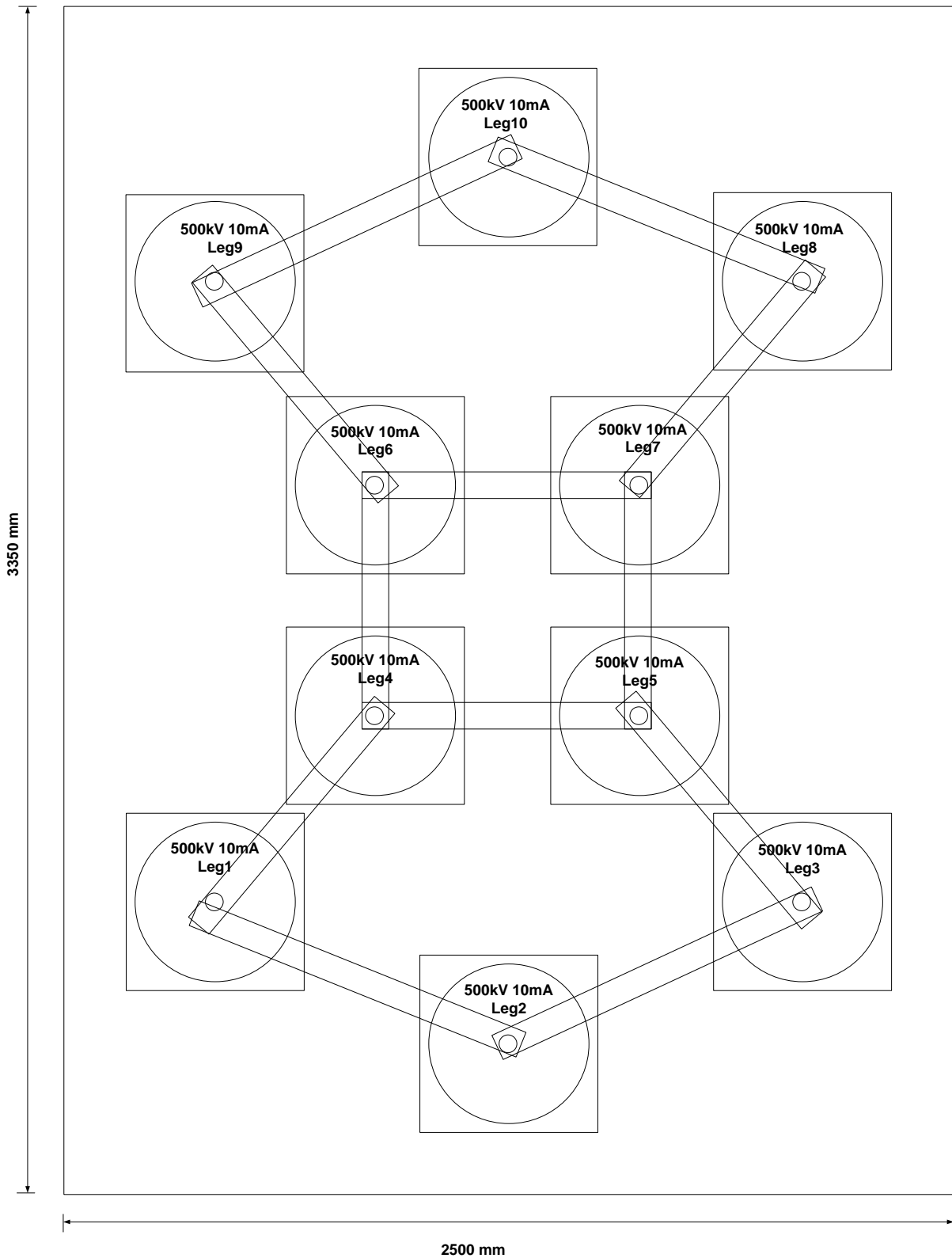


Figure 7: Alternate Plan view of 500kV DC, 100mA HV Load Bank modules Assembly

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Annexure – II **TECHNICAL BID COMPLIANCE**

Bidder must submit along with the bid the following documents –

- a) Conceptual technical proposal including electrical schematics, GA drawings etc.
- b) Component Selection, Datasheet and Tentative Bill of Material
- c) Temperature rise analysis and calculations
- d) The material specifications of all the parts of the HV tank including accessories and fittings.
- e) Technical Compliance sheet duly filled in data against each parameter.
- f) Tentative contract execution schedule defining major activities / milestones

During the evaluation of technical bids, IPR shall review the submitted technical proposal and may seek further clarifications/discussions with the bidder to ascertain feasibility or viability of the same. If the proposal is found to be incapable of meeting the technical specifications, the bid shall be technically disqualified.

Technical Compliance Sheet for 100 kV DC Load Bank Module

Sr. No.	Parameters	IPR Requirement	Bidder's Specification
1.	Site Condition:		
a)	Ambient Temperature (maximum/minimum/average (annual))	47 °C / 4 °C / 35 °C	
b)	Relative Humidity (maximum / minimum)	90 % / 17 %	
c)	Altitude	55 meters above MSL	
d)	Installation	Indoor	
2.	Load Bank Specifications		
a)	Application	To Test and Characterize HV DC Power Supply at different voltage and current ratings	
b)	Constructional	Modular for ease of obtaining the required voltage and current rating.	
c)	Rated Voltage	100 kV DC.	
d)	Rated Current	10 mA	
e)	Rated Power	1 kW	
f)	DC isolation from the HV terminal to grounded point	120 kV DC	
g)	Operating duty cycle	30 Minutes ON / 90 Minutes OFF.	

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a)	Resistance Value	10 MΩ to draw 10 mA at 100kV DC (Single Module)	
b)	Temperature coefficient	Less than 500 ppm/ °C	
c)	Tolerance	±5% or less	
d)	Type of Resistor	Non inductive metal film Resistors with metallic caps on the ends suitable for oil immersed operation	
e)	Make of Resistor & Model No.	Nicrom / Ohmite / Vishay / Metallux/ Kanthal/ Genvolt/ TT Electronics/ Caddock/ HVR/SML Resistors/EBX	
f)	Cooling	Oil natural air natural	
g)	Insulating medium	EHV grade Mineral oil	
h)	HV Tank material	Polypropylene Fiberglass Tank	
i)	HV Termination	Through HV feed through/anti corona ring with metal links for different current selection (off load type).	
j)	Configuration	The basic module shall have the provision (off load type) for connecting series/parallel combination of various modules for different voltage/current selection.	
k)	Overall dimensions of 100 kV DC/10 mA single module	≤ 900 mm height ≤ 400 mm diameter OR ≤ 100 liters volume	
l)	Accessories (Specify the make and model no.)	<ul style="list-style-type: none"> a) Earthing rod- FRP rod with brass spade end and suitable length (5 meters) of flexible cable b) Trolley (10 Nos.) having bi directional wheels with suitable locking mechanism to mount 5 stacks of load bank modules c) Metal Links/HV Capsule for 	

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		connecting various 500kV DC, 10mA Legs d) Corona balls of suitable diameter (10 Nos.) with a provisions to fix at top anti-corona flange of each 500kV DC, 10mA legs.	
m)	Quantity	50 nos.	
n)	Applicable Standards	IEC 60060-1:2010 (Edition 3.0 2010-9)/ IEC 60060-2:2010(Edition 3.0 2010-11) and as applicable	