TECHNICAL SPECIFICATION

FOR

500 kV, 100 mA DC SYMMETRICAL COCKCROFT-WALTON VOLTAGE MULTIPLIER (CW-MULTIPLIER) UNIT

INSTITUTE FOR PLASMA RESEARCH

BHAT, GANDHINAGAR – 382 428

GUJARAT, INDIA

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1. SCOPE OF SUPPLY

The scope of supply incudes Design, Engineering, Assembly, Factory Acceptance Testing, and Supply, Installation and Site Acceptance Testing of 500 kV, 100 mA DC Symmetrical (Full wave) Cockcroft & Walton Voltage Multiplier (CW-Multiplier) Unit and Spares at Institute for Plasma Research (IPR), Gandhinagar as per the detailed technical specification (including annexures) 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 Symmetrical Cockcroft-Walton Voltage Multiplier (CW-Multiplier) unit as per technical specifications specified in Section-4.
b) Submission of detailed engineering design report/documents, Quality Plan and detailed Schedule as mentioned in Section-7 for IPR's review and approval.
c) Development/Procurement and Assembly of all passive and active electrical components viz. Resistor, Inductors, Capacitors, Diodes, Multiplier HV and LV Bushing & Feed-through assembly, End Terminations including Clamps & Connectors, HV Tank with fittings & accessories etc. as per technical specifications and as may be required for complete design and development of 500kV, 100mA DC Voltage Multiplier Unit.
d) Supply of spares of all type as per technical specifications.
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-6.1
g) Upon receipt of dispatch clearance note from IPR, Pack and Deliver the power supply unit at IPR site as per Section-7.
h) Installation of CW-Multiplier unit (Refer Section-7).
i) Perform the Site Acceptance Tests (SAT) as per Section-6.2.
j) Provide operational and instruction manuals with full technical details. (Refer Section-7).
k) Provide training of the operation and maintenance for minimum 2 people at IPR.
l) Provide FAT and SAT reports with all tests results, to the IPR before final acceptance.
m) Provide technical support / supervision as required during CW-Multiplier unit Integration with other sub-systems (including control system interface, input AC connection and output DC connection etc.) and Commissioning of DC Power Supply (DCPS) system as per Section-6.3.
n) Provide technical support as per warranty clause.

3. APPLICATION DESCRIPTION

The 500 kV, 100 mA DC Symmetrical CW Voltage Multiplier (CW-Multiplier) Unit is intended to supply High Voltage Power to DC Particle Accelerators of rating up to 500 keV/50 kW. The voltage multiplier unit at the source end is interfaced with Single phase, High Frequency (20 kHz), Centre-tap, Step-up (400 V / 25kV- 0-25 kV RMS) transformer. At the load end the multiplier unit is coupled with DC Particle Accelerator

and/or Load Bank (for performance testing). The output voltage of CW-Multiplier unit shall be control and regulated from front end HFPS unit as shown in Figure-1.

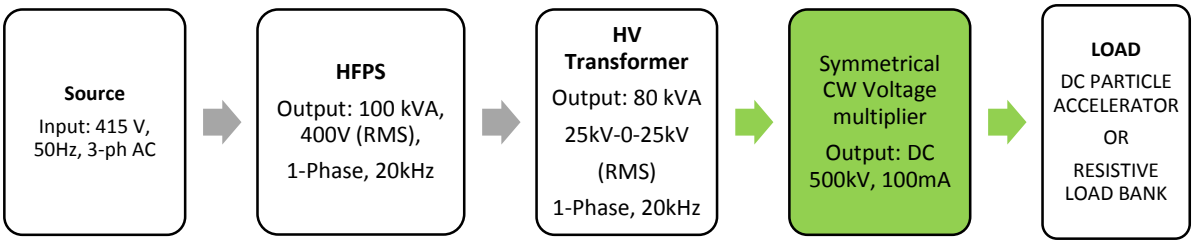


Figure 1: General Block Diagram of 500 kV, 100 mA DC Power Supply

4. TECHNICAL SPECIFICATIONS

The CW-Multiplier unit shall be designed and manufactured/assembled as per technical specification defined in Table-1.

Table 1: Technical Specification of Voltage Multiplier Unit

Sr. No.	Parameter	IPR requirement
1.	Input Specification	
a)	Input Power	80 kVA
b)	Input voltage	25kV-0-25kV(RMS),
c)	Input Voltage Waveform	Sine wave
d)	Input Voltage Frequency	20 kHz
e)	Operating Temperature Range	0 ^{o}C to 50 ^{o}C
f)	Relative Humidity	10 % to 90 %
2.	Output Requirement	
a)	Voltage Multiplier Type	Symmetrical (Full Wave) Cockcroft Walton (CW)
b)	Rated output current I_{Load}	100mA
c)	Rated DC output voltage V_{OUT}	500 kV
d)	Number of Multiplier stages	As required to produce 500 kV at 100 mA at the output
e)	Output ripple Voltage (percentage)	< 0.5% (of rated value)
f)	Voltage Regulation (No-Load to Full Load)	≤ 20 %
g)	Polarity(with respect to chassis ground)	Positive
h)	Efficiency	> 85% at Full Load or better
i)	Duty Cycle	Continuous
j)	Cooling	Natural / Forced air cooling
k)	Insulating medium	Dry Pressurized Nitrogen gas
l)	Voltage rating of Diode and Capacitor Stack	≥ 90 kV
m)	Current rating of Diode and Capacitor Stack	≥ 1.5 A

n)	Protection	i. Thermal Overload: 110% ii. Short circuit: 10 A. iii. Over voltage: > 600 kV iv. Sequential arcing fault (and any other as required for reliable operation of the unit)
o)	Installation	Indoor
3.	CW-Multiplier termination	
a)	Input LV Bushing/Feed-through with clamp/connectors	i. Voltage Class – 36 kV ii. Insulation – Epoxy Cast / Synthetic Rubber /Porcelin/Ceramics iii. Clamp/Connectors - Copper
b)	Output HV Bushing/Feed-through with clamp/connectors	i. Voltage Class: > 245 kV ii. Insulation – Epoxy Cast / Synthetic Rubber /Porcelin/Ceramics iii. Clamp/Connectors – Copper
4.	HV Tank	
a)	Material	Carbon Steel
b)	Design shape	Shell / Cylindrical
c)	Design pressure	Internal – 97 psi / External – 15 psi
d)	Design operating temperature	+ 20 ^{o}C to + 60 ^{o}C
e)	Design, Fabrication, Testing and Inspection Code	ASME boiler and pressure vessel code section VIII division-I 2001 edition
5.	Applicable Standards	IEC 60060 Part- 1 (1989) / IEC 60060 Part- 2(1994) and as applicable

5. TECHNICAL REQUIREMENTS

5.1. General:

a) The CW-Multiplier unit shall be developed in number of stages/decks as may be required to obtain 500 kV, 100mA DC output.

b) The CW-Multiplier unit shall be designed against all possible internal and external faults viz. over-voltage, short-circuit and internal serial arcing/flash-over. Necessary passive protective elements viz. resistors/inductors, spark gaps of required rating shall be included in multiplier circuit assembly.

c) Arcing Phenomenon: The CW-Multiplier should tolerate the internal and external (load) arcing. Suitable protective devices / components should be incorporated to limit the magnitude of arc current (through a current limiting resistor) and di/dt (through an inductor) without deviating from the technical specifications.

d) All the devices/components shall be rated/de-rated with the repetitive arcing phenomenon in consideration. This arcing might be frequent during the initial testing period and unit's performance should not get degraded. The design of CW-Multiplier unit shall ensure that, if an arc occurs across its terminals, it shall ensure path of arcing current completes within its loop and shall not damage the other low voltage electronics systems inside/nearby.

e) The CW-Multiplier unit shall be provided with an internal serial arcing fault detection device / circuit or as applicable.
f) Bidder shall select good quality of CW-Multiplier circuit active and passive components viz. diodes/diode stack, capacitors/capacitor stack, resistors/resistor stack etc. and shall be of appropriate rating based on thermal, static and transient operating electrical conditions.
g) Suitably rated LV and HV bushing/feed-through assembly for CW-Multiplier input and output termination respectively shall be provided with necessary clamp/connectors.
h) The material of HV and LV bushing shall be homogeneous, non-porous, and free from blisters burns and other defects.
i) The Multiplier HV and LV bushings/feed-through assembly shall be adequately mounted on top OR bottom cover of the HV tank as per the design feasibility and sealed in order to make it leak proof. Sealant shall be gas compatible and non-conductive.
j) Creepage and clearances: Generally in accordance with IEC or IS standard to be ensured during the design.
k) The CW-Multiplier unit shall be designed to compensate the effect of stray capacitance if any by inserting necessary inductor to facilitate proper voltage built up at each stage and at the output terminals.
l) The CW-Multiplier unit shall be assembled as per the Full Wave CW voltage multiplier topology and housed in a High Voltage Tank filled with pressurized dry nitrogen gas.
m) Spacers or post Insulators shall be used to make the vertical structure of CW voltage multiplier unit. The spacers/insulators shall be of high dielectric strength to avoid any flash over in the system and have enough mechanical strength to withstand the weight of each multiplier stage components.
n) All the insulating material on which the multiplier components and protection devices are mounted shall be of dry nitrogen compatible.
o) Bidder shall ensure inter stage electrical connections with the help of high voltage connectors for a trouble free connectivity and for the ease in the assembly of the vertical stacking.
p) Bidder shall ensure the assembly without any sharp metallic points or any sharp soldering joints or welding joints.
q) Necessary fire and personnel safety guidelines/regulations for indoor installations as applicable shall be complied.
r) Proper corona guard rings shall be used to keep the electric field strength within safe limits.

5.2. Electrical:

a) All the termination (electrical cables entries) points shall be easily accessible to reduce the complexity while operation, alteration and maintenance activities.
b) All the current carrying parts shall be separated by physical barriers to ensure safety. All the terminals except AC earth shall be electrically isolated.
c) Input terminals of the HVPS unit shall be clearly marked as 25 kV – 0 – 25 kV and output terminals as + 500 kV.

d) There should be a clear and prominent "DANGER" Marking at the terminal block.
e) All insulated conductors except those within the confines of a PCB assembly, shall be of the suitable ratings, which are enough to withstand the maximum current and voltage during overload and/or fault/abnormal conditions.
f) All wiring shall be neatly secured in position and adequately supported. Where cables/wires pass through the metal panel; suitable size of cable glands shall be used. All the wires and cables used shall be of low smoke zero halogen fire retardant as per IS 1554 and IS 694 or IEC 61034 with latest amendments and they shall be properly rated to prevent excessive heating. Proper indication on cable shall be provided for all the cables.
g) The associated AC, DC connections, control, alarms and interface cable connecting the unit shall be connected/disconnected easily without causing any interruption in the supply and damage to load or other circuits. All live parts AC, DC, and control, alarm and monitoring cables interconnecting the units shall be easily disconnected by plugs and connectors.

5.3. HV Tank:

a) Bidders shall consider the following materials for manufacturing of HV Tank.
    - For shell/tank body: Carbon steel plate as per ASTM – A515/A515 M Grade 70.
    - For tank top and bottom flat cover: FRP (Grade G10 or better) / PEEK plate as per ASTM / ASME Section X
    - For Flanges: Carbon steel forging as per ASTM A105/A105M
    - For Pipes used for ports: Seamless carbon steel pipes as per ASTM: A106-99
    - For bolts: as per ASTM A193/A193 M Grade B-7
    - For Nuts: ASTM A 194/A194M Grade 7
    - Welding consumables: Covered Electrodes: ASME SFA-5.1 class E7016/7018
    - For non-pressure parts (e.g. supports): IS 2062 or equivalent.
b) Under operating conditions the tank/vessel shall be filled with oil free gases, like Sulphur-hexafluoride gas (SF6), Air, N_2. Before filling of vessel with gases, tank is to be evacuated to 10 mbar. After filling the gas the pressure inside the tank shall be 6 bar (88 psig), which is maximum operating pressure.
c) The tank needs to be provided with safety relief valve and a rupture disc in parallel. The safety relief valve shall be of spring loaded direct action type. The rupture disc shall be of compression loaded reverse buckling type with hinge design. Both these safety devices shall be of reputed make preferably from Audco or BS&B.
d) A digital reading pressure gauge which can display the pressure up to 230 psig with resolution of 1 psig is to be provided on the tank. The gauge must be calibrated and of reputed make.
e) The tank shall be designed to permit lifting by crane or jacks of the complete voltage multiplier unit filled with nitrogen gas. Suitable lugs and bolts shall be provided for this purpose.
f) Bidder shall design the tank of suitable size which can enclose voltage multiplier assembly with enough precautions in view of electrical insulation and a strong mechanical support to hold multiplier assembly.

g) The tank top/bottom shall be provided with a detachable cover with a bolted flanged gasket joint. The material used for gasket shall be cork neoprene or equivalent. The gasket joints for tank, bushings and other bolted attachment shall be so designed that the gasket will not be exposed to the weather and gaskets are not crushed.
h) The tank shall be designed to fix the voltage multiplier assembly on top/bottom cover with suitable provisions for tanking/un-tanking the voltage multiplier assembly for maintenance or to repair/replacement of part/ component.
i) Provisions for easy connection and dis-connection of end terminations (HV and LV) and cables shall be provided.
j) The body of the tank shall be thoroughly cleaned and should have a smooth surface. The body shall be painted with a poly-eurithene (PU) anti tracking coat.
k) Necessary measures shall be adopted like increased clearance / separate non-magnetic shields to minimize eddy current losses.
l) Bidder shall provide safe and secured midpoint grounding arrangement firmly connected to HV Tank or as per design feasibility.
m) Necessary fittings and accessories/fixtures as suitable and appropriate including for lifting, moving, piping for gas filling/evacuating shall be provided.
n) Terminal marking, rating name plate, danger sign and general multiplier scheme display shall be fitted on to tank body.

5.4. Monitoring and Protection:

a) High voltage diagnostics: The critical characteristics like bandwidth, response, full-scale values, impedances etc., of the measuring units /transducers such as high voltage dividers, DC and pulse current transducers should be appropriately rated to meet/or exceed the technical specifications.
b) Bidder shall provide signals for measurement and protection as per Table-2. All the measured signals shall be derived to give an output of 0 to 10 V. Protection signals shall be of potential free contact (PFC) type
c) The ratio, accuracy class and burden of the sensors shall be suitably selected.
d) Any parameter for measurement and protection not mentioned in the Table-2 but require to improve the reliability shall be added by the bidder.

Table 2: List of signals to be provided for Measurement and Protection

Sr. No.	Particulars	Data	Signals
1.	Output dc voltage	0 - 500 kV (DC)	(0 to 10V)
2.	Output dc current	0 - 100 mA (DC)	(0 to 10V)
3.	Input source AC voltage (both terminals)	0 – 35kV (peak)	(0 to 10V)
4.	Lower Deck DC Voltage(1st Stage)	0 – 70 kV	(0 to 10V)
5.	Lower Deck DC Current (1st Stage)	0 – 1 A	(0 to 10V)
6.	HV Tank Gas Temperature	0 – 100 ^{o}C	(0 to 10V)
7.	HV Tank Gas Pressure	0- 230 psig	(0 to 10V)
8.	HV Tank Gas Temperature (Alarm and Trip)	+ 60 ^{o}C	Potential Free Contract (PFC)
9.	HV Tank pressure (Trip)	97 psi	PFC
10.	Arcing fault (Trip)		PFC

5.5. Spares:

Following items shall be supplied as spares –

a) Diodes of all type and ratings – 20 % of actual quantity used
b) Capacitors of all type and ratings – 20% of actual quantity used
c) Resistors of all type and ratings – 20% of actual quantity used
d) Inductors of all type and ratings – 20% of actual quantity used
e) Multiplier HV and LV bushing/Feed-through assembly with clamps and connectors – 1 number each
f) Gaskets – 1 set
g) Tank fittings & accessories – 1 number of each type
h) Insulators and spacers of all type and ratings – 20 % of actual quantity used

5.6. List of preferred/Recommended Makes of Components:

The CW-Multiplier circuit components preferably selected from makes as defined in Table-3. Makes other than listed below may be considered on proper justifications, data sheets, and reliability factors provided by the bidder.

Table 3: Preferred/Recommended Make List of Components

Sr. No.	Component	Make
1.	HV Capacitors	Murata Electronics / TDK Corporation/Vishay/ /Illinois Capacitors/Calramic Technologies/ HVCA /AVX
2.	HV Diode	HVCA/Vishay/Voltage Multiplier INC.(VMI)/ Microsemi
3.	HV Resistor	Nicrom/OHMITE/ Vishay / BI Technologies /IRC/ Welwyn /Genvolt
4.	HV & LV bushings	BHEL / WS Industries / Modern Insulators / Aditya Birla Insulators

6. ACCEPTANCE TESTING

6.1. Factory Acceptance Tests:

The following are some major tests that are to be performed by the supplier to demonstrate compliance of the CW-Multiplier unit as per the contract specifications prior to the shipment. All the related test equipment, fixtures, measuring instruments, test-setup etc., shall be arranged by the supplier. Supplier shall submit a FAT template to IPR for review and approval. The details of the test template and testing procedure shall be done on mutual agreement after the award of contract. IPR representative shall witness the FAT at manufacturer's works.

The factory acceptance tests (FAT) are listed as follow. For demonstration of output voltage at no load condition, source will be provided by the IPR. The tests not mentioned below, but required to validate the performance/characterization of voltage multiplier unit shall be included and performed by the bidder.

a) Visual inspection of CW-Multiplier unit (including its accessories and discrete components) assembly.
b) High voltage withstand tests across individual stage (at 90 kV)

c) Demonstration of Output Voltage at no load condition (1hr) – Subject to source provided by IPR.
d) Linearity check for output voltage with respect to variation in input voltage – Subject to source provided by IPR.
e) Hydrostatic Test: The tank is to pass a hydrostatic test at 162 psig as per UG99 of ASME sec VIII div. 1
f) Leak Testing: The air-soap bubble leak test is to be carried out on tank at 88 psig after hydrostatic test. No leak from any joint of the tank is permitted. The Helium MSLD test is also to be carried out by evacuating the vessel up to 10^{-5} bar and the leak rate should not be more than 10^{-8} mbar.lt/s.
g) Rupture disc and safety valve operation demonstration.

For pressurization and MSLD test all necessary arrangements are to be made by the manufacturer/supplier. The detailed test report including the test results shall be prepared by the supplier and submitted to purchaser for approval/ acceptance for dispatch clearance.

6.2. Site Acceptance Tests:

After the installation of CW-Multiplier unit at IPR site the SAT shall be performed in-line with FAT by the supplier. IPR at its discretion may prescribe all or a reduced subset of FAT tests to be performed at the IPR site.

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.

6.3. Integrated & Commissioning Tests:

ONLY TECHNICAL SUPPORT / SUPERVISION TO BE PROVIDED

Upon complete installation and integration of each sub-system/unit (including HFPS Unit, HV Transformer, CW-Multiplier Unit, and Load) of DCPS system, the integrated and commissioning tests shall be performed to verifying the stability and functionality of the complete 500 kV, 100 mA DC Power Supply System. The DCPS will be connected to 3-Phase 415 V input line and tested upto 500 kV, 100 mA DC on resistive load bank. During the tests all functions shall run concurrently and equipment/devices shall run in continuous mode. The integrated system tests shall include but not limited to the following tests:

- Heat run test shall be carried out within rated parameters for 8 hours of continuous operation. During this test crucial performance parameters mentioned in the specification like voltage regulation, input power factor, overall efficiency etc., shall be checked.
- Checking of all monitoring and protection parameters as listed in this tender document from Local control panel and Remote PC.

7. CONTRACT MANAGEMENT

7.1. 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 may include; design, component procurements, manufacturing, FAT, delivery milestone, installation and SAT etc.

7.2. Quality Assurance Plan (QAP):

The CW-Multiplier unit shall be manufactured in conformance with the international and/or national standards/codes as applicable to assure the quality and reliability of the CW-Multiplier unit. Bidder should specify the applicable standard followed. 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.

7.3. Engineering Design Report (EDR):

After the award of contract, supplier should submit an Engineering Design Report (EDR) for the CW-Multiplier unit based on the technical proposal submitted during the bid for IPR approval. This report shall include following minimum submission documents (but not limited to) -

a) Design calculations (electrical, thermal, mechanical etc.) and simulation reports including selection, and sizing of components shall be submitted
b) Engineering design and drawings including GA drawings and electrical schematic drawings.
c) The detailed fabrication procedure and drawings of tank which shall include all the manufacturing details and tolerances.
d) Cabling diagram and cable schedule with proper terminal block numbering.
e) List of all accessories, hardware and bill of materials (BOM).
f) Test certificates and data sheets of all the bought-out major components viz. HV Capacitors, Fast recovery HV Diodes, HV Resistors for Diode Voltage Equalization, Damping resistors, HV divider, HV Bushing/Feed-through, LV bushing/Feed-through, current/voltage measuring sensors, Protective Elements, etc. used for making of CW-Multiplier unit shall be provided.

7.4. Factory Acceptance Tests (FAT):

FAT shall be performed by the supplier to demonstrate compliance of the CW-Multiplier unit as per contract specifications before effecting the shipment, as per Section-6.1.

7.5. Operating and Instruction Manual:

The supplier shall submit 3 sets of document / technical literature in English language 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.

7.6. 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 CW-Multiplier unit 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.

7.7. 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 the HFPS unit is to be installed is situated at ground floor level in IPR New Auxiliary Building.

7.8. Unloading and Storage:

Bidder is responsible for unloading of the CW-Multiplier unit 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 CW-Multiplier unit and accessories shall be stored at Bidder's responsibility until final acceptance and taking over by IPR.

7.9. Installation:

Bidder is responsible for installation of the following items-

- CW-Multiplier unit and accessories.
- Piping for pressurize N_2 gas.

Any material or accessory which may not have been specifically mentioned but which is necessary shall be supplied at no extra cost to IPR.

7.10. Site Acceptance Tests (SAT):

SAT shall be performed by the supplier to demonstrate compliance of the CW-Multiplier unit as per contract specifications after effecting the installation, as per Section-6.2.

7.11. 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 the CW-Multiplier unit. The date of issuance of final acceptance note shall be considered as the date of final acceptance.

7.12. Training:

The supplier has to arrange technical training of two representatives from IPR either at manufacturing site or at IPR mutually agreed upon to familiarize about various sub-systems, operation and maintenance of CW-Multiplier. The cost of travel and stay (if any) will be borne by IPR.

7.13. Warranty:

Supplier should provide a minimum of one year standard warranty for all the deliverables (CW-Multiplier unit 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.

Annexure - I

CW-MULTIPLIER UNIT CONCEPTUAL DESIGN DESCRIPTION

CW-Multiplier unit as mentioned in Section-3 and shown in Figure-2 below shall be integrated at site with HFPS unit and HV Transformer to generate 500 kV, 100 mA DC Power output. The DC Power Supply shall be connected to Resistive Load Bank for integrated testing and commissioning of 500 kV, 100 mA DC Power Supply (DCPS) system.

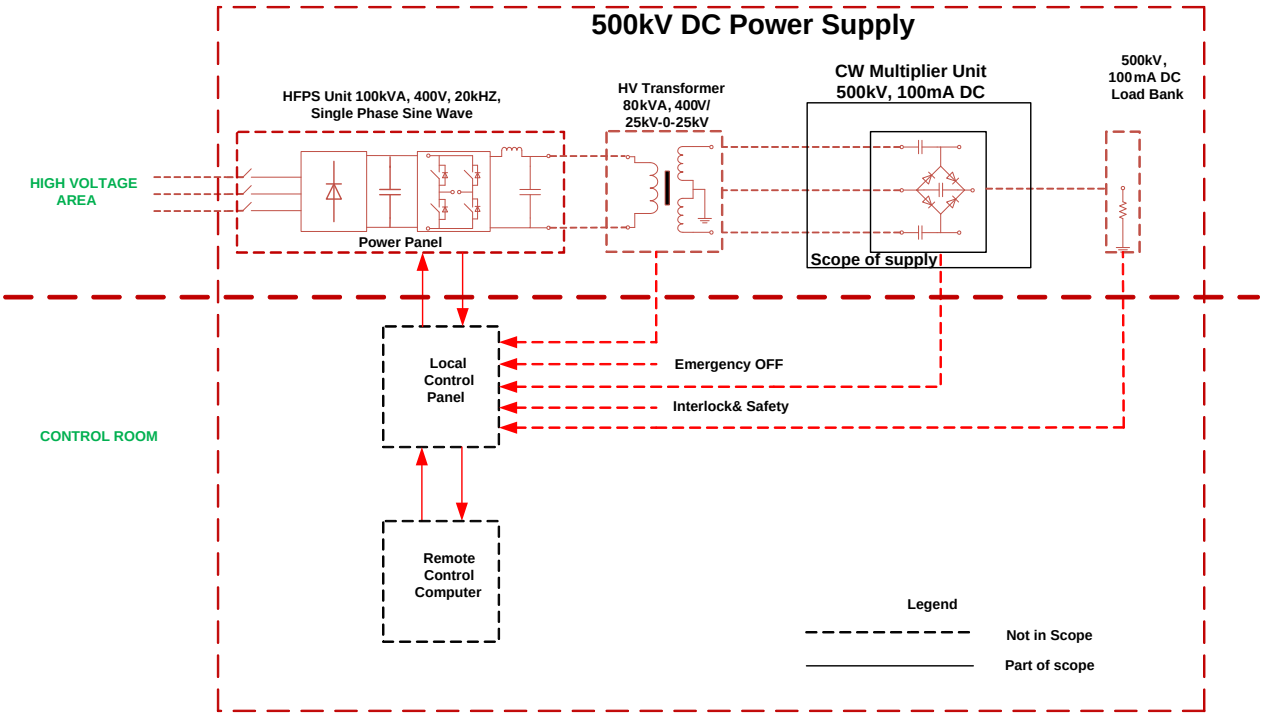
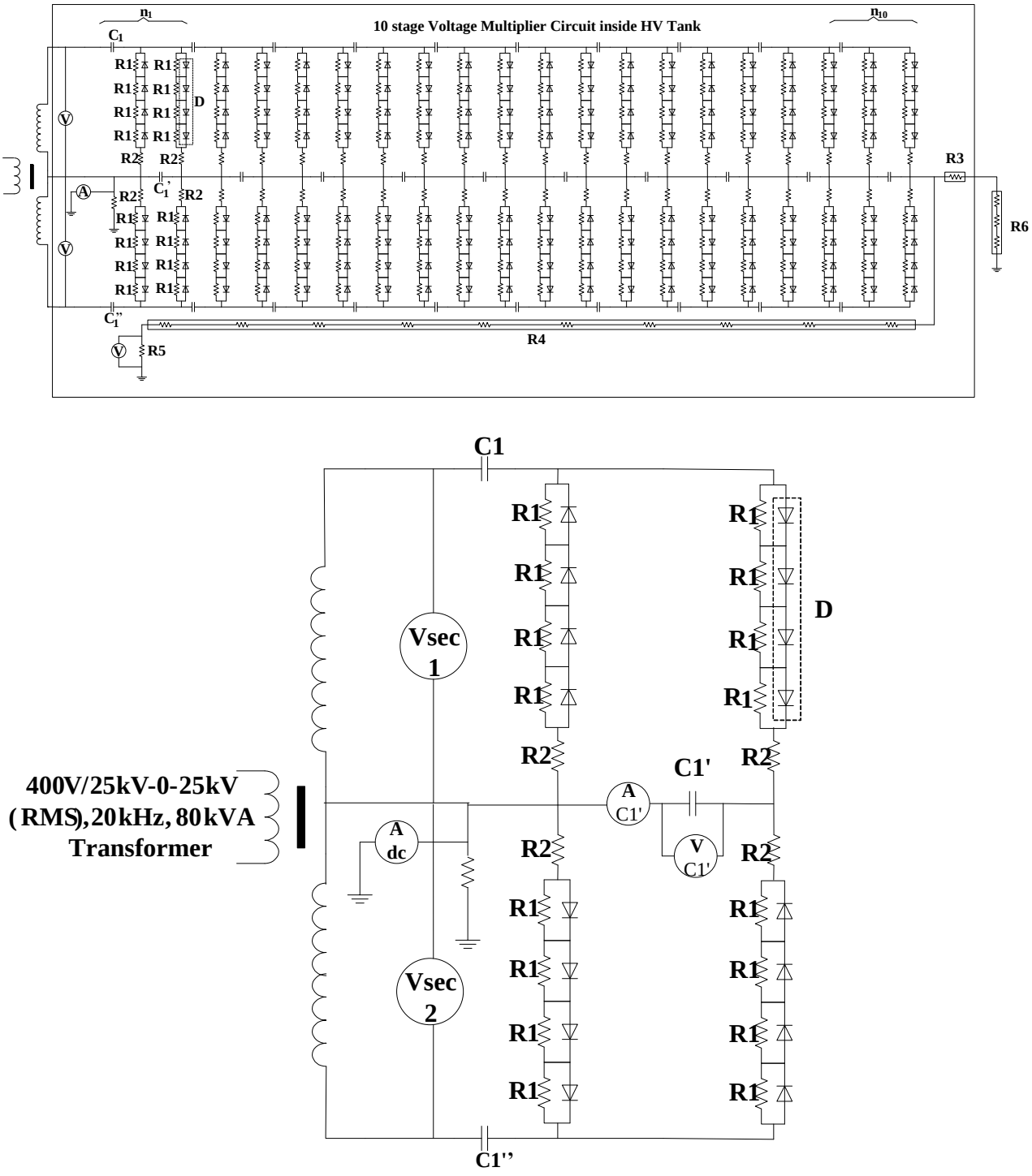


Figure-2: CW-Multiplier Unit Integration Diagram

The conceptual design and drawings developed of 500 kV, 100 mA DC CW-Multiplier unit is provided in this section. Changes in this conceptual design and drawings may be possible based on feasibility, bidder's skills and availability of the components in market. The design data considered for developing the conceptual design are given in Table-3.

Table 4: Conceptual Design Data

Sr. No	Parameters	Data
1.	Input source	25 kV-0-25 kV (RMS), 20 kHz, 80 kVA, Sine wave
2.	On Load Output Voltage	500 kV
3.	No Load Output Voltage	600 kV
4.	Output Current	100 mA
5.	Ripple	< 0.5 %
6.	Regulation (no load to full load)	20% or better
7.	Stored energy	< 2.0 kJ
8.	Short circuit current	10 A
9.	Leakage current (through voltage divider)	100 µA
10.	Electrical stress limit	5 kV/mm



R1: Diode Equalizing Resistor - 25GΩ, 1W, 25kV; HV Diode - 90kV, 1.5A; R2: Diode Surge Current Limiting Resistor - 10kΩ, 10W, 90kV; R3: Output Current Limiting Resistor - 100 kΩ, 2 kW, 500kV; R4: Voltage Divider HV arm– 5 GΩ, 10k: 1 Ratio; R5: LV arm (500 kΩ); R6: HV Load;
HV Capacitor - 25nF, 90kV (C1=C1'=C1'')

Figure 3 - Electrical Schematic of 500kV, 100mA DC Symmetrical Cockcroft-Walton Voltage Multiplier (CW-Multiplier) Unit

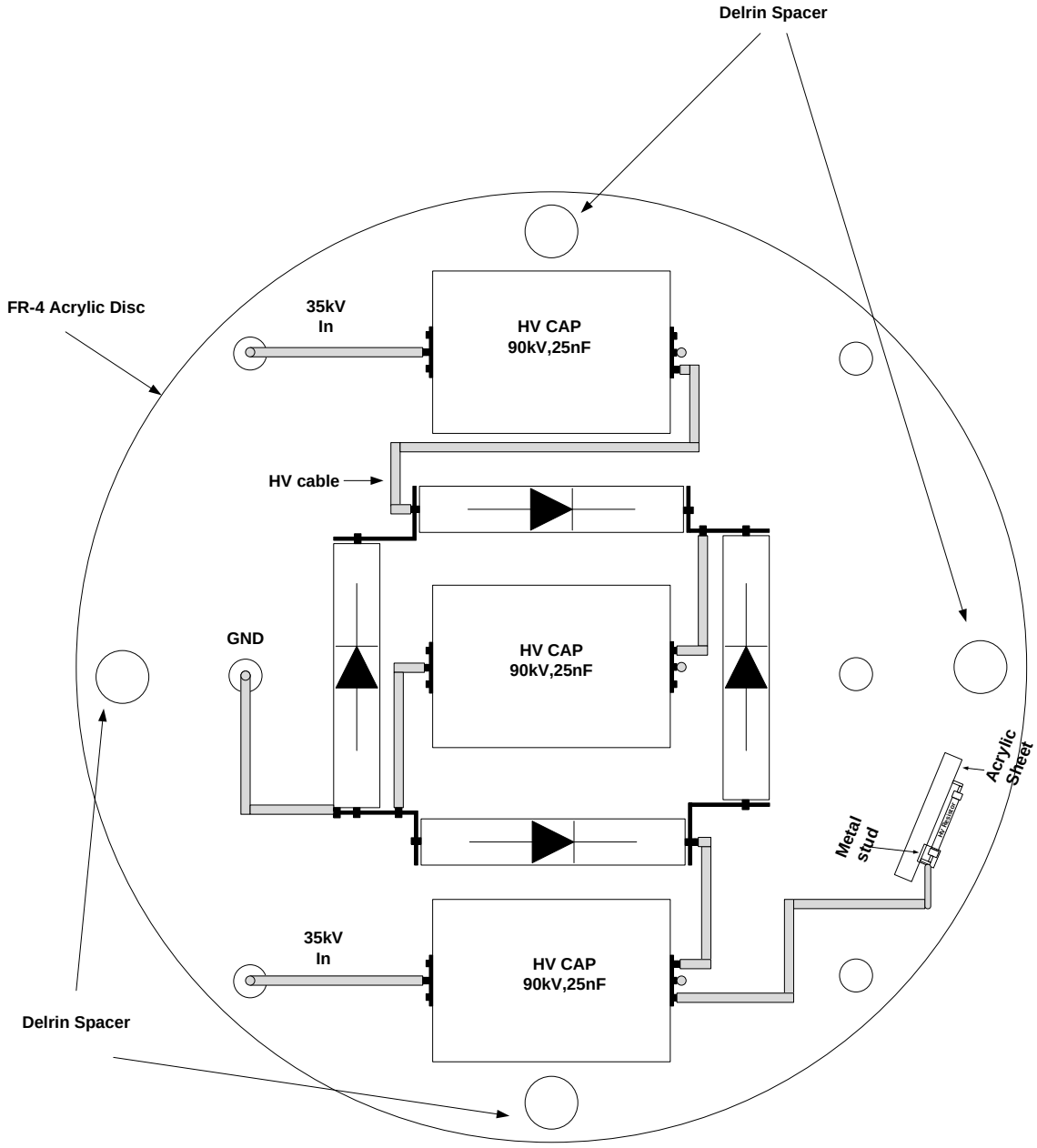


Figure 4 – Top View of Voltage Multiplier components assembly on FR-4 Acrylic sheet

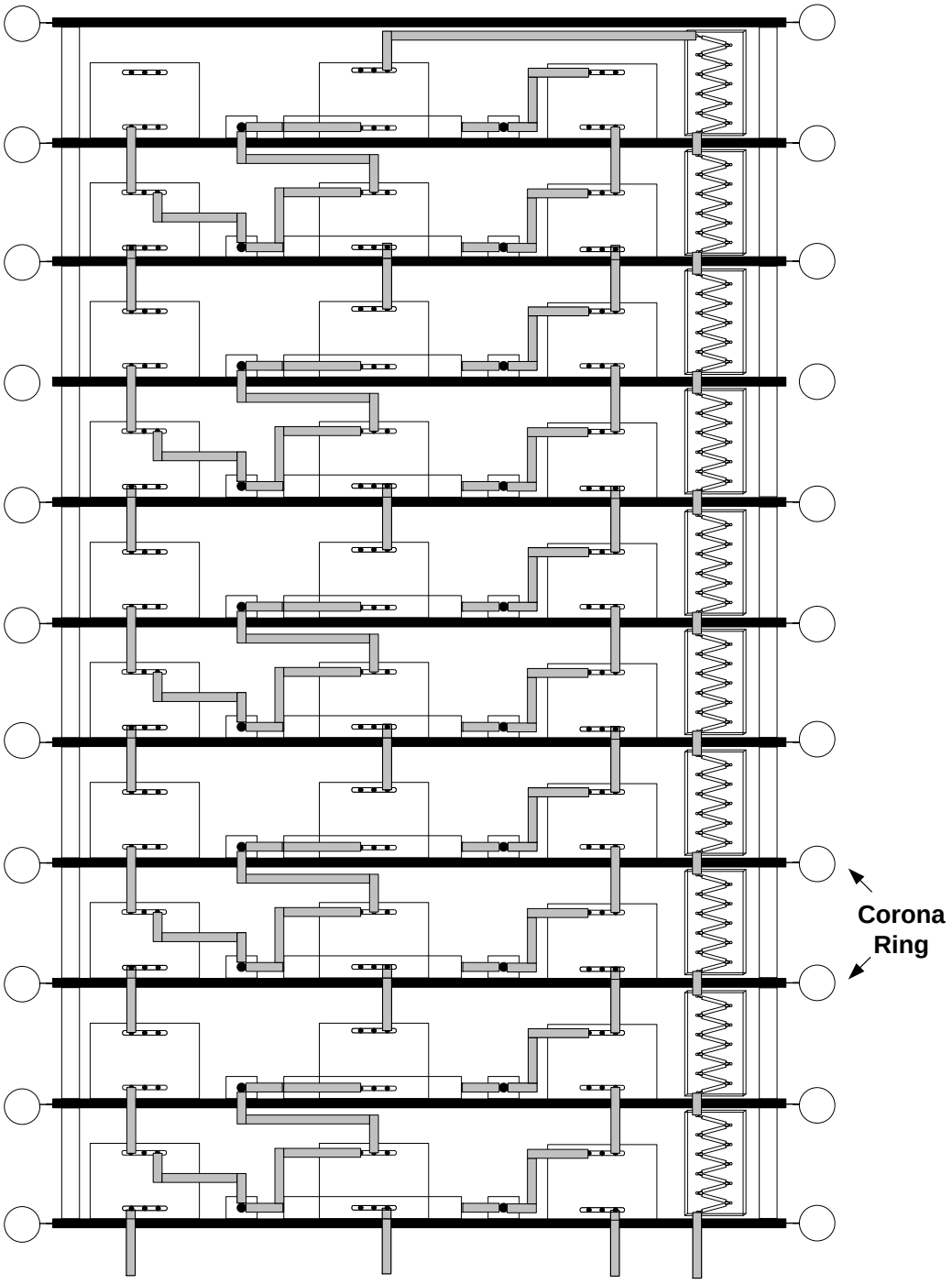


Figure 5 - Cross Sectional View of CW-Multiplier assembly inside the HV tank

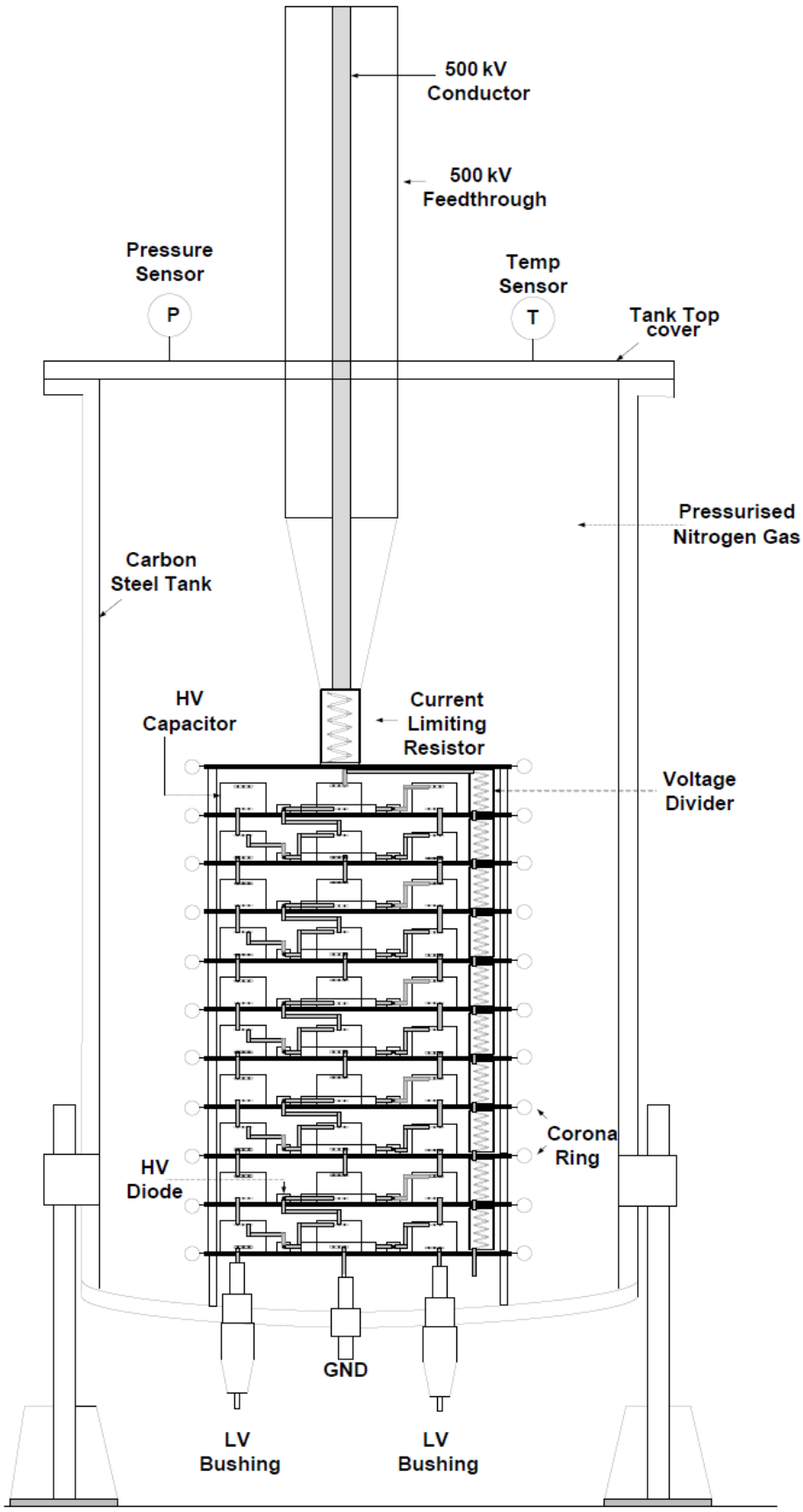


Figure 6 - Cross Sectional View of CW-Multiplier Assembly inside the HV tank

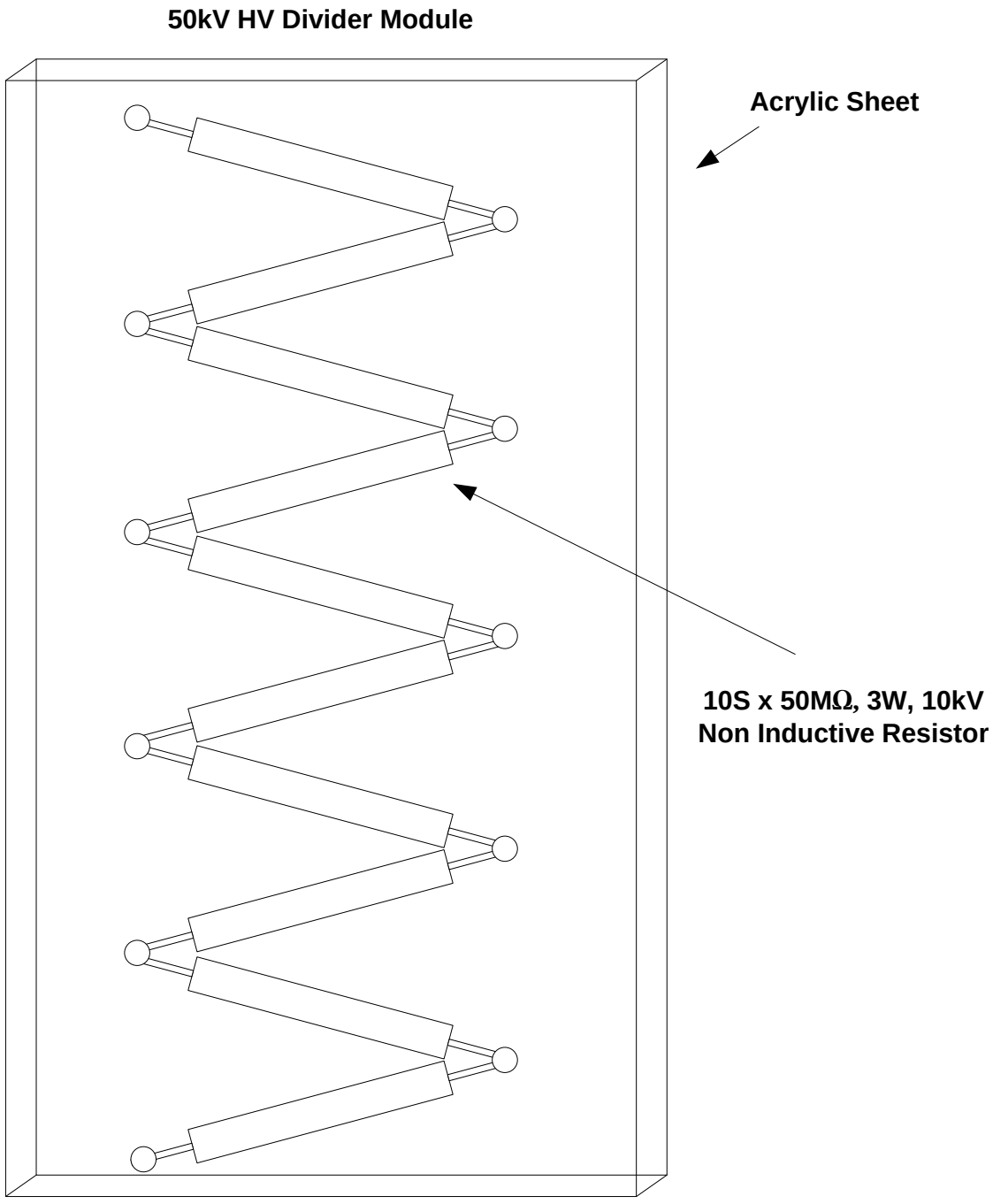


Figure 7 - HV Resistive Divider Module for Single Stage (50kV) Voltage Multiplier

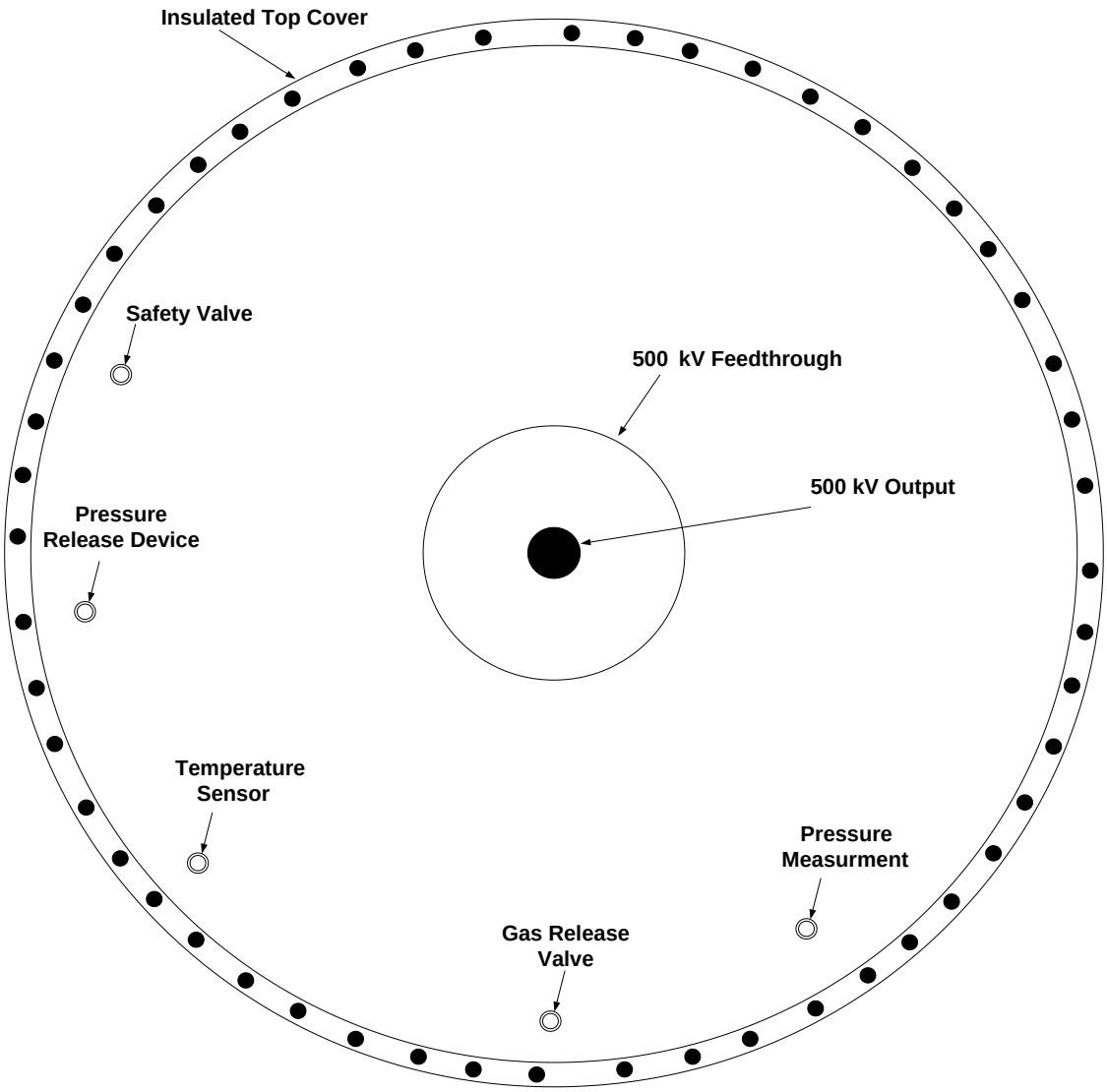


Figure 8 – HV Tank Top Cover with 500 kV Feed-through

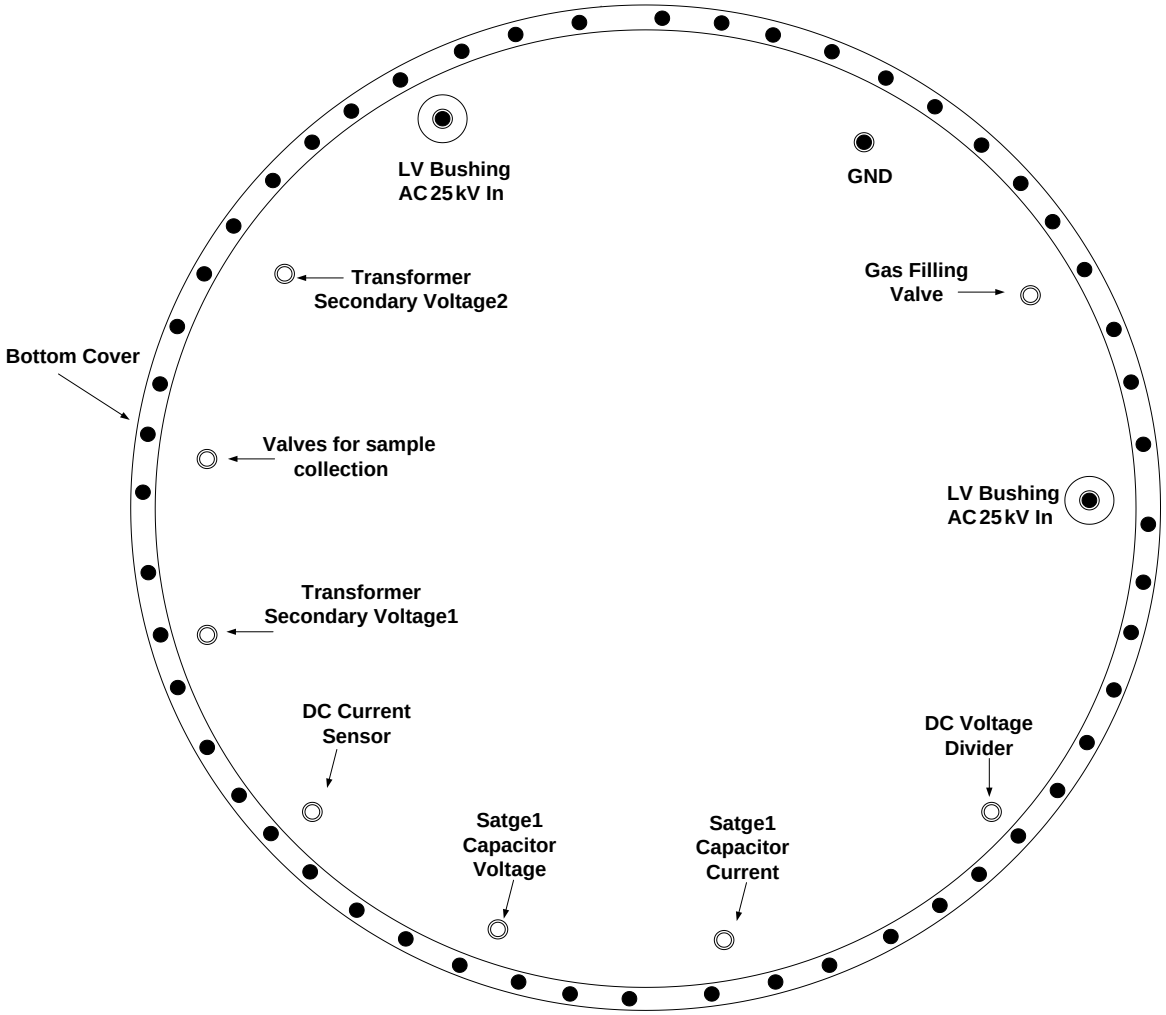


Figure 9 – HV Tank Bottom Cover with LV Feed-through

THE DESIGN, SCHEMATIC AND ASSEMBLY DRAWINGS ARE TO BE CONSIDERED FOR REFERANCE ONLY. VENDOR MAY PROSPOSE/SUBMIT HIS OWN DESIGN AND DRAWINGS ALONG WITH BID FOR EVALUATION.

Annexure-II
TECHNICAL BID COMPLIANCE SHEET
(Bidder must submit along with the bid the following documents)

a) Conceptual technical proposal including GA drawings, Block Diagrams etc.
b) Thermal analysis and basis of components selection
c) Losses, efficiency, and stored energy calculation
d) Tentative Bill of material (BOM)
e) Material specification of major parts of HV Tank
f) Proof of concept/topology together with simulation report/results
g) Data Sheet (Table-5) duly filled in data against each parameter. Just filling **"complied"** shall not be accepted, the actual value have to be indicated.
h) 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.

Table 5: Data Sheet

Sr. No.	Parameter	Unit	Bidder's Specifications
1.	General		
a)	Name of Manufacturer		
b)	Input voltage	Volt	
c)	Input Voltage Waveform		
d)	Input Voltage Frequency	kHz	
e)	Operating Temperature	^{o}C (maximum)	
f)	Relative Humidity	%	
2.	Design		
a)	Voltage Multiplier Type	Provide tentative schematic design & drawing with simulated results.	
b)	Rated output current I_{Load}	mA	
c)	Rated DC output voltage V_{OUT}	kV	
d)	Number of Multiplier stages	Number	
e)	Capacitance Value	nF	
f)	Output Ripple Voltage (of rated value)	%	
g)	Voltage Regulation (No-Load to Full Load)	%	
h)	Maximum Stored Energy	Joules	
i)	Polarity (with respect to chassis ground)	Positive / Negative	

j)	Capacitor / Capacitor Stack Voltage Rating	kV	
k)	Capacitor / Capacitor Stack Current Rating	A	
l)	Capacitor make, type, material, tolerance etc…	Provide necessary data sheet	
m)	Diode / Diode Stack Voltage Rating	kV	
n)	Diode / Diode Stack Current Rating	A	
o)	Diode make, type, material, tolerance etc…	Provide necessary data sheet	
p)	CW-Multiplier Efficiency (at Full Load)	%	
q)	Duty Cycle	%	
r)	Cooling	Natural / Forced air cooling	
s)	Insulating medium		
t)	Installation	Indoor/Outdoor	
u)	Protection	List all protections provided including the details of protective element viz. resistors/inductors/relay etc.	
v)	Installation	Indoor / Outdoor	
3.	Measurements		
g)	Output DC Voltage measurement	Provide the level of voltage measurement/sensor type, accuracy and burden (VA)	
h)	Output DC Current measurement	Provide the level of current measurement/sensor type, accuracy and burden (VA)	
i)	Do the first stage DC Voltage/Current measurement provided?	If yes, Provide the level of voltage / current measurement/sensor type, accuracy and burden (VA)	
j)	Do the input AC voltage measurement provided	If yes, Provide the level of voltage measurement/sensor type, accuracy and burden (VA)	
4.	CW-Multiplier Termination		
a)	Input LV Bushing/Feed-through with clamp/connectors	Provide material, make, type and rated voltage class	
b)	Output HV Bushing/Feed-through with clamp/connectors	Provide material, make, type and rated voltage class	
5.	HV Tank		
a)	Material		
b)	Design shape		

c)	Design pressure	Internal (psi) / External (psi)	
d)	Design operating temperature	^{o}C	
e)	Design, Fabrication, Testing and Inspection Code	Provide the design code to be followed	
f)	Do pressure relief valve/device provided? If yes provide, type, make and model no.	Provide necessary data sheet	
g)	Do safety valve provided? If yes, provide, make, type, model no.	Provide necessary data sheet	
h)	Do the pressure and temperature measurement provided?	If yes, Provide the level of pressure/temperature measurement/sensor type, accuracy.	
i)	Fittings and accessories	Provide the list of all fittings & accessories	
j)	Over all Dimensions	meters	
k)	Un-tanking height	meters	
l)	Weight of empty tank	kg	
m)	Total weight with CW-Multiplier assembly and fittings.	kg	
6.	Applicable Standards		