ANNEXURE - I

Technical specification of

1) 3.3 kV, 100kVAR at 60 Hz, 24.4 µF, Capacitor Bank (three phase) and

2) 3.3 kV, 25kVAR at 60 Hz, 6.09 µF, Capacitor Bank (three phase) along with structures

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1	**SCOPE** The purpose of this document is to provide the technical specification of the Capacitor Banks (labelled C(3.3)1 and C(3.3)2) used in Temperature rise test facility to perform Temperature rise test on MV/HV Circuit Breakers, MV/HV Switchgear and Controlgear, MV Bus Ducts, HV Switches and HV Disconnectors. Scope includes design, engineering, manufacturing, stage inspection, testing, mandatory spares, transportation, insurance, loading, unloading, installation and commissioning of Capacitor banks (labelled C(3.3)1 and C(3.3)2) along with structures for three phases, insulators, capacitors connections links, bus-bars supported by suitable insulators for parallel and delta connection as per fig (2), (3), (4), (5) and (6), excluding disconnector and earth switch.
2.0 **2.1**	**GENERAL INFORMATION** **General Service Conditions** The climatic conditions prevalent at the site of the operation are as follows; a) Altitude above Mean Sea Level : 920 m b) Maximum ambient temperature : 45°C c) Minimum ambient temperature : 10°C d) Average annual temperature : 24°C e) Average Humidity : 81% f) Special corrosion conditions : Nil g) Solar Radiation (DNI) : 4.5-5.0 kWh/Sq. m/Day h) Atmospheric UV radiation : High i) Pollution level : – Outdoor : SCD 25 mm/kV (USCD 43.3 mm/kV) – indoor : SCD 20 mm/kV (USCD 34.7 mm/kV) j) Snow fall : Nil k) Seismic Zone : Zone-II l) Wind Speed : Average 5.6 km/h m) Annual rainfall : 1000mm-1500mm
3.0	**REFERENCE STANDARD** For the definition of technical parameters, performances and any other prescriptions given in this Technical Specification, reference has to be made with the latest edition of the following Standards: 1) IEC 60871-1, Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 1: General 2) IEC 60871-2, Shunt capacitors for a.c. power systems having a rated voltage above 1000 V - Part 2: Endurance testing Moreover reference has to be made to all applicable Indian laws.

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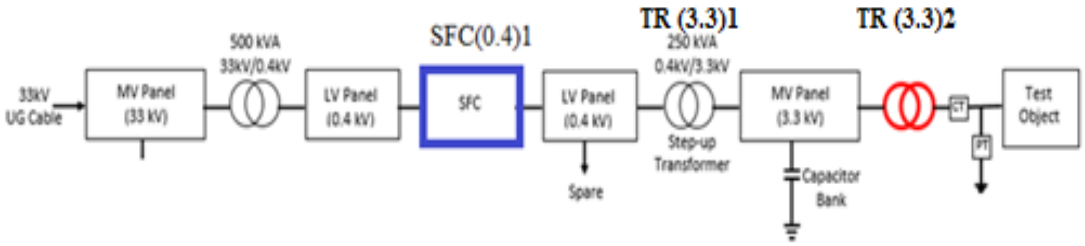
4.0	**EQUIPMENT MAIN FUNCTIONAL FEATURES** The Capacitor Banks are located in the test circuit between the Step-up Transformer (labelled TR(3.3)1) and Step-down Transformers (labelled TR(3.3)2) and are able to supply a large share of the reactive power requested by the Temperature rise tests in order to reduce the power supplied by the Supply Network, as shown in below figure.  The test circuit consists of three-phase Capacitor Banks and details are as follows: • the **Capacitor Bank C(3.3)1** making use of 162 capacitors, each one with a rated power of 100 kVAr at 60 Hz (24.4 µF) and 3.3 kV rated voltage • the **Capacitor Bank C(3.3)2** making use of 15 capacitors, each one with a rated power of 25 KVAr at 60 Hz (6.09 µF) and 3.3 kV rated voltage. The above reported values are referred to a rated frequency of 60 Hz, the same capacitors can be used also at a rated frequency of 50 Hz with the same rated voltage and a rated power 1.2 times lower. The physical arrangement of Capacitor Banks C(3.3)1 and C(3.3)2 are shown in figure 1. The arrangement of compensating capacitor banks are as follows: • the three-phase Capacitor Bank C(3.3)1 consists of three single-phase banks each of which is arranged in three floors always connected in parallel as shown in fig. 2, and its multiline connection diagram is shown in figure 3. The illustrative arrangement of one phase of Capacitor banks both side view and top view are shown in figure 4. • the three-phase Capacitor Bank C(3.3)2 is arranged in three floors, one for each phase as shown in fig. 5, and its multiline connection diagram is shown in figure 6. The capacitors in each floor of the Capacitor Banks are grouped in blocks as shown in the Fig.2 & 3 for C(3.3)1 and Fig.5& 6 for C(3.3)2. The capacitors of each block are parallel connected through a segment of bus-bars, while the blocks are parallel connected by means of disconnectors whose switching operations are remote controlled through pressurized air operated by electro-valves.

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Such configuration of the three-phase Capacitor Banks allows to obtain:

the total capacitance in the range from 24.4 µF up to 1317.6 µF with a step of 24.4 µF, for each phase of the Capacitor Bank C(3.3)1;
the total single-phase capacitance in the range from 6.09 µF up to 30.45 µF with a step of 6.09 µF, for each phase of the Capacitor Bank C(3.3)2.

The three single-phase of the Bank C(3.3)1 may be connected:

in parallel between them, in case of single-phase tests,
in delta configuration, in case of three-phase tests.

The three floors of the Capacitor Bank C(3.3)2 may be connected:

in parallel between them, in case of single-phase tests,
in delta configuration, in case of three-phase tests.

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5.1</td><td>
TECHNICAL REQUIREMENTS
Capacitors:
The capacitors, each one enclosed in a hermetically sealed housing and lying on the bank frame. The Capacitors of the banks shall meet the main technical requirements below reported.
Table 1 –
Main supply technical requirements of the two three-phase Capacitor Banks
<table>
<tr><th rowspan="2">Parameter</th><th colspan="2">Value</th></tr>
<tr><th>C(3.3)1</th><th>C(3.3)2</th></tr>
<tr><td colspan="3">Capacitors:</td></tr>
<tr><td>• Installation</td><td colspan="2">Outdoor</td></tr>
<tr><td>• Number of capacitors for each 3-phase Bank</td><td>162 +
9 nos. (Spares)</td><td>15+
3 nos. (Spares)</td></tr>
<tr><td>• Capacitance at 60Hz</td><td>24.4 µF</td><td>6.09 µF</td></tr>
<tr><td>• Capacitance Tolerance</td><td colspan="2">From -%5 up to 10 %</td></tr>
<tr><td>• Rated reactive power at 60 Hz</td><td>100 kVAr</td><td>25 kVAr</td></tr>
<tr><td>• Rated Voltage</td><td>3300 V</td><td>3300 V</td></tr>
<tr><td>• Rated current at 60 Hz</td><td>30.4 A</td><td>7.6 A</td></tr>
<tr><td>• Rated Frequency</td><td colspan="2">50 Hz and 60 Hz</td></tr>
<tr><td>• Discharge resistor(1)</td><td colspan="2">Built-in</td></tr>
<tr><td>• Tangent of loss angle (tanδ)</td><td colspan="2">Less than 0.2×10^{-3}</td></tr>
<tr><td>• Duty</td><td colspan="2">Continuous</td></tr>
<tr><td>• AC test voltage between terminals</td><td colspan="2">7.2 kV_{rms}</td></tr>
<tr><td>• AC test voltage between terminals and case</td><td colspan="2">10 kV_{rms}</td></tr>
<tr><td>• Lightning impulse withstand voltage</td><td colspan="2">40 kV_{peak}</td></tr>
<tr><td>• Short-circuit discharge test</td><td colspan="2">8.3 kV_{dc}</td></tr>
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Capacitor bushing terminals:			
• Number	2		
• Rated voltage	3.6 kV		
• Rated current	31.5		10 A
• Power Frequency (PF)	10 kV_{rms}		
• Lighting Impulse (LI)	40 kV_{peak}		
• Min total creepage distance	90 mm		
• Min. clearance between terminals	60 mm		
• Final part of terminals	Threated for fixing the bus-bar through nuts		
Capacitors block:			
• Number of blocks for each single-phase Bank	54 capacitors per Phase bank.		5 capacitors per Phase bank.
• Number of capacitors for each block	Each phase bank has 3 floors, total 18 capacitors per floor. Floor 1 has 5 blocks, total 18 capacitors. Floor 2 has 1 block, total 18 capacitors. Floor 3 has 1 block, total 18 capacitors. See Figure 2, 3 & 4		Each phase bank has 3 blocks, total 5 capacitors. See Figure 5 & 6

[(1)] In accordance with IEC Standards 60871-1 clause 21, the incorporated discharge resistor must ensures a reduction of the residual voltage to 75V in less than 10 minutes.

5.2

Banks and relevant Bus-bars

In the following the main technical characteristics of the frame and four types of bus-bars to be used are listed in Table 2.

Table 2 – Banks and Bus-bars main technical requirements

Parameter	Value	
	C(3.3)1	C(3.3)2
Bank frame:		

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	• *Insulation*	Grounded	Grounded
	• *Cooling*	Natural	
	• *Structure*	Steel galvanized	
	Segment bus-bars for each block:		
	• *Material*	Copper or Aluminum	
	• *Rated voltage*	3.6 kV_{rms}	
	• *Rated current*	600 A	20 A
	• *Short-time withstand current*	10 kA_{rms}, 1 s	
	• *Power Frequency (PF)*	10 kV_{rms}	
	• *Lightning impulse (LI)*	40 kV_{peak}	
	Bus-bars for parallel connections of the blocks:		
	• *Material*	Copper or Aluminum	
	• *Rated voltage*	3.6 kV_{rms}	
	• *Rated current*	1700 A	40 A
	• *Short-time withstand current*	10 kA_{rms}, 1 s	
	• *Power Frequency (PF)*	10 kV_{rms}	
	• *Lightning impulse (LI)*	40 kV_{peak}	
	Bus-bars for delta and parallel configuration of the three-phase Bank:		
	• *Material*	Copper or Aluminum	
	• *Rated voltage*	3.6 kV_{rms}	
	• *Rated current*	3400 A	80 A
	• *Short-time withstand current*	10 kA_{rms}, 1 s	
	• *Power Frequency (PF)*	10 kV_{rms}	
	• *Lightning impulse (LI)*	40 kV_{peak}	
	Bus-bars connecting the Bank to the test circuit:		
	• *Material*	Copper or Aluminum	
	• *Rated voltage*	3.6 kV_{rms}	
	• *Rated current*	5000 A	120 A
	• *Short-time withstand current*	10 kA_{rms}, 1 s	
	• *Power Frequency (PF)*	10 kV_{rms}	
	• *Lightning impulse (LI)*	40 kV_{peak}	

6.0 DESIGN RECOMMENDATIONS AND SAFETY MEASURES:

The equipment has to be designed, manufactured and tested in accordance with the best international engineering practices under stringent quality control to meet the requirement stipulated in the technical specifications. Adequate safety margin with respect to thermal, mechanical, dielectric and electrical stress etc. are to be considered during design, selection of raw material, manufacturing process.

The manufacturer shall take all necessary measures to ensure the safety of the test operator during the execution of the tests.

The features and construction details of the sub-system/component included in each of the two Capacitor Banks C(3.3)1 and C(3.3)2 shall be in accordance with the

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	requirement given in the following.
6.1	**Capacitors:** The capacitors shall be characterized by a very high degree of reliability and long life. The capacitor case, made of electrically welded sheet steel, is able to withstand the normal stress produced by breakdowns. The case surface shall be sandblasted and then painted with several layers of single-component paint in order to efficiently avoid rust, even in highly aggressive environments. The elasticity of the surfaces of the case compensates for the variations in the volume of the impregnating liquid in the operating temperature range. At low temperatures the elasticity of the case must ensure that there will not be an inner depression that reduces the dielectric strength of the oil and the voltage of partial discharges. At high temperatures, conversely, the elasticity of the case must ensure that the internal overpressure be limited. The housing also has two handles for lifting and fixing the capacitor to the frame. The oil impregnates all the individual capacitive elements of which the capacitor is composed, and fills the entire free volume, ensuring perfect isolation and absence of partial discharges. Impregnating substance must be a non-toxic, biodegradable, synthetic oil. The capacitor terminals are to be located on porcelain bushing. The porcelain bushings are to be metalized for both fastening to the capacitor cover and for fixing to the screw terminal connections. The bushings shall be perfectly sealed and particularly sturdy.
6.2	**Banks** The Banks shall be designed taking into account the dimensions of the capacitors and disconnectors and a minimum height of the frames allowing an easy scheduled maintenance or a substitution of capacitors in case of fault. Considering that the two Banks are in electric parallel to the test circuit supplied by the Static Frequency Converter which do not admit any downstream located circuit-breaker, no circuit-breakers addressed to protect the Banks are to be installed. The mounting rack and pedestal shall be galvanized steel members with all galvanizing carried out after completion of cutting, drilling and punching. All bolts, nuts and washer which are used in the no current parts shall be hot dip galvanized steel or stainless steel. In each Bank there are four types of aluminium or copper bus-bars: a) bus-bars addressed to parallel connection of the capacitors in each block; b) bus-bars addressed to perform the parallel connection of the blocks involved in the test;

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	c) bus-bars addressed to perform the parallel and delta connection of the three-phase; d) bus-bars addressed to perform the connection of the Bank to the test circuit. The bus-bars type a) must be drilled in order to allow the fixing of the capacitor terminals through nuts. The bus-bars types a), b) and c) shall have a rectangular cross section, while the bus-bars type d) shall have a terminals suitable for the connection to the test circuit bus-bars.
7.0	**TESTS TO BE PERFORMED:** The type, routine and acceptance tests to be performed on the two Capacitors C(3.3)1 and C(3.3)2 are listed in the following paragraph. Total cost of test charges are added to the main equipment cost.
7.1	**Type tests:** The supplier can submit reports of type tests performed on similar equipment provided that a full demonstration is given that such similar equipment are fully representative of the supplied equipment. In absence of such report, the supplier has to perform the type tests on the supplied equipment. Making reference to the IEC Standard 60871-1 the following items have to be taken into account on the Capacitors of the Banks C(3.3)1 and C(3.3)2, respectively: ✓ Thermal stability test, ✓ Measurement of tangent of the loss angle (tanδ), ✓ AC voltage test between terminals, ✓ AC voltage test between terminals and case, ✓ Lightning impulse voltage test between terminals and case, ✓ Short-circuit discharge test, ✓ Endurance test making reference to IEC Standard 60871-2.
7.2	**Routine tests:** The supplier shall inform the routine tests program 60 days in advance and shall allow customer representatives to witness them. Making reference to the IEC Standard 60871-1 the following items have to be taken into account on the Capacitors: ✓ Capacitance measurement , ✓ AC voltage test between terminals, ✓ AC voltage test between terminals and case, ✓ Test of internal discharge device, ✓ Sealing test.
7.3	**Acceptance test:** The Acceptance Tests at costumer's site are aimed to demonstrate that the supplied

Clause No.	TECHNICAL SPECIFICATION
	equipment was correctly assembled, fulfils its technical specification and complies with the relevant standards. The supplier shall made available all the reports concerning the type, special and routine tests performed. The Acceptance Tests shall be considered successfully carried out if the supplied items are verified by check of the content of delivery for completeness.
8.0	**STRUCTURAL WORK** Structures for capacitor banks shall be installed in the specified area with a maximum height of 5 meters and its dimensions are shown in Fig. (1). Structures for capacitor banks shall be designed as per the floor requirements and dielectric requirement shown in Fig.(2), Fig.(3), Fig.(4), Fig.(5) and Fig.(6). The structures shall be sized according to the size of capacitors, permanent load of capacitor banks (as per floor), climatic overloads proper to the site and to operation overloads especially electrodynamic forces produced by the Capacitor banks. Supplier shall provide for earthing of structures. The structures shall be protected against climatic conditions with primer coat and finish coat as per relevant Indian standard. The drawings of structural work along with capacitors/bank dimensions shall be submitted to CPRI for approval.
9	**INSPECTION DURING MANUFACTURING** The supplier shall carry out a comprehensive inspection and testing program (some of the tests above specified) on the two Capacitor Banks during and at the end of the equipment manufacturing. The detailed inspection and testing program shall be agreed between purchaser and manufacturer. CPRI representatives shall be allowed to inspect the production process in the factory. To this purpose the supplier shall inform CPRI of the test program execution 60 days in advance.
10	**INSTALLATION AND COMMISSIONING** The supply shall include the installation and commissioning activities performed by a team of specialized workers of the Supplier. These activities will be performed in a period defined by the Purchaser, in order to avoid interferences with other works.
11	**SPARE PARTS** The supplier must provide for the different components of the equipment the MTBF (mean time between failures) and MTTR (mean time to repair), the time requested for the delivery of the replacement parts and shall suggest an appropriate list of spare parts as well as shall provide the equipment necessary for the maintenance operation not requiring his intervention.

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12	**TECHNICAL INFORMATION TO BE SUPPLIED** The following technical information shall be included in the bid: •Type of capacitors (such as High gradient metallized polypropylene, Bimetallized paper); •Technical characteristics of capacitors (capacitance and relevant tolerance, rated voltage, tanδ, rated current); •Structure drawing and specification of the different component (frame, insulators); •Tests certificates relevant the type tests specified; •Dimensions (length, width and height) [mm]; •Mass [kg]; •List of the suggested spare parts. The following documents shall be provided along with the supply: •General drawings, electrical schemes, installation drawings. •Operational manual and Maintenance manual: these manuals shall include specific instruction relevant to the handling, installation, troubles shooting and servicing. •Reports on inspection during manufacturing. •Reports of routine and acceptance tests. All documents shall be issued in English language and provided both on paper and software copy.

Figure 1

SITE ARRANGEMENT PLAN FOR CAPACITOR BANK C(3.3)1 & C(3.3)2

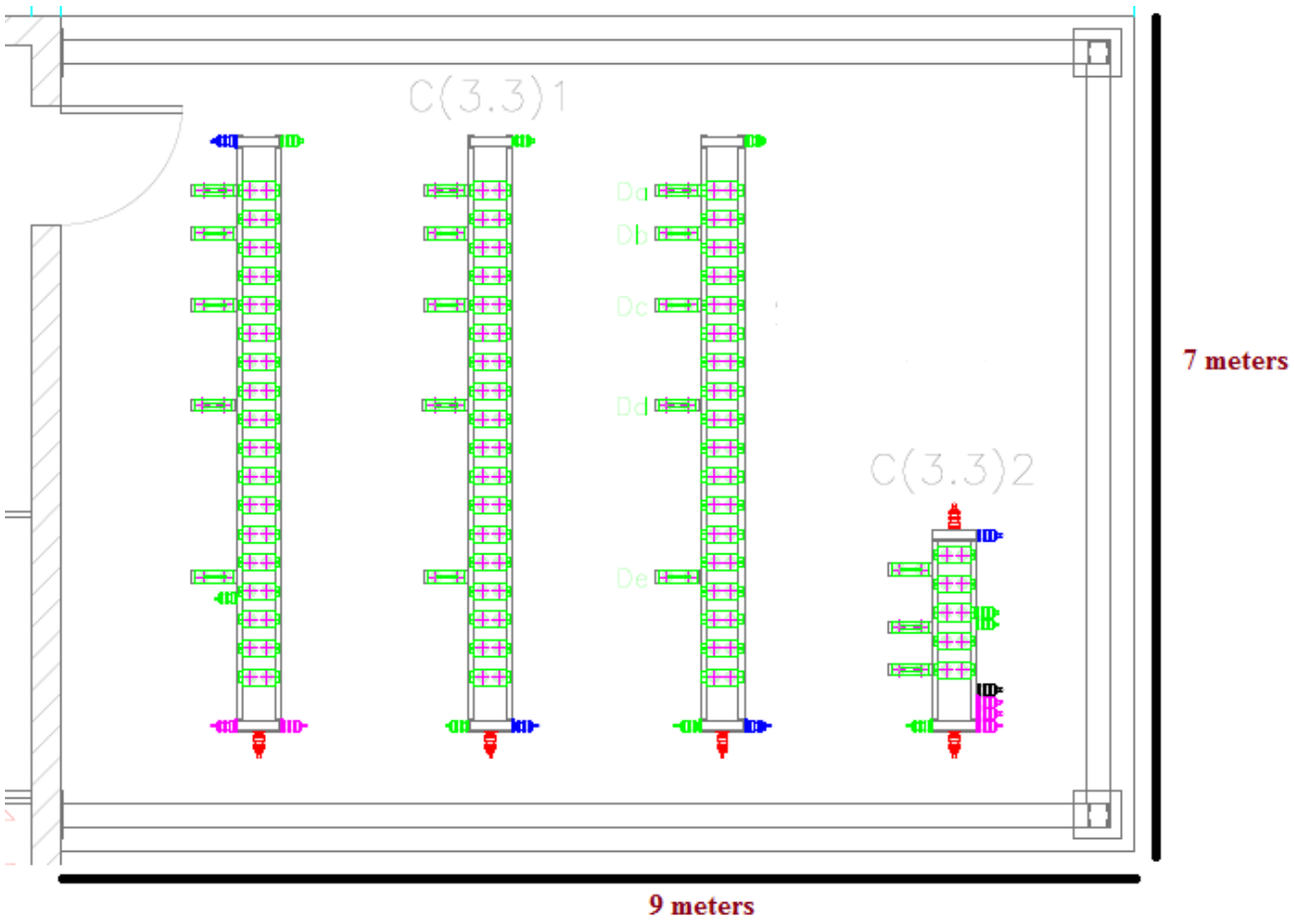

Figure 2

BLOCKS AND RELEVANT NUMBER OF CAPACITORS ON EACH FLOOR OF THE CAPACITOR BANK C(3.3)1

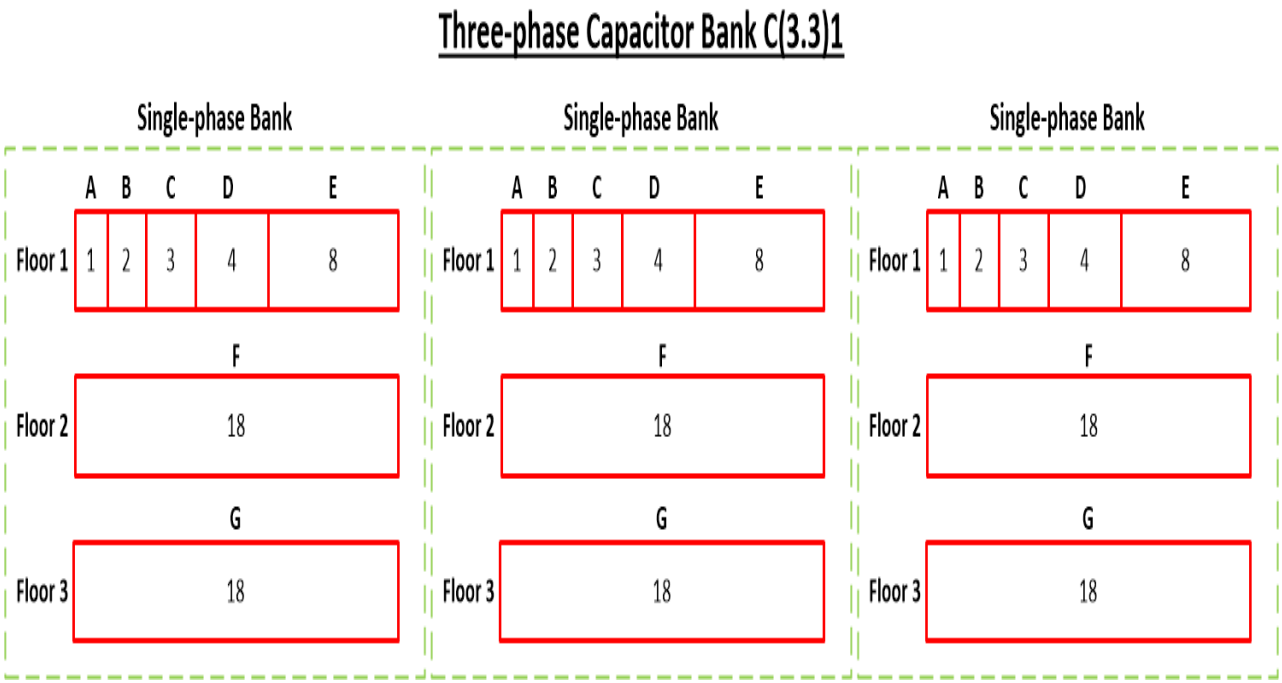

Figure 3

CAPACITOR BANK C(3.3)1 MULTI LINE DIAGRAM

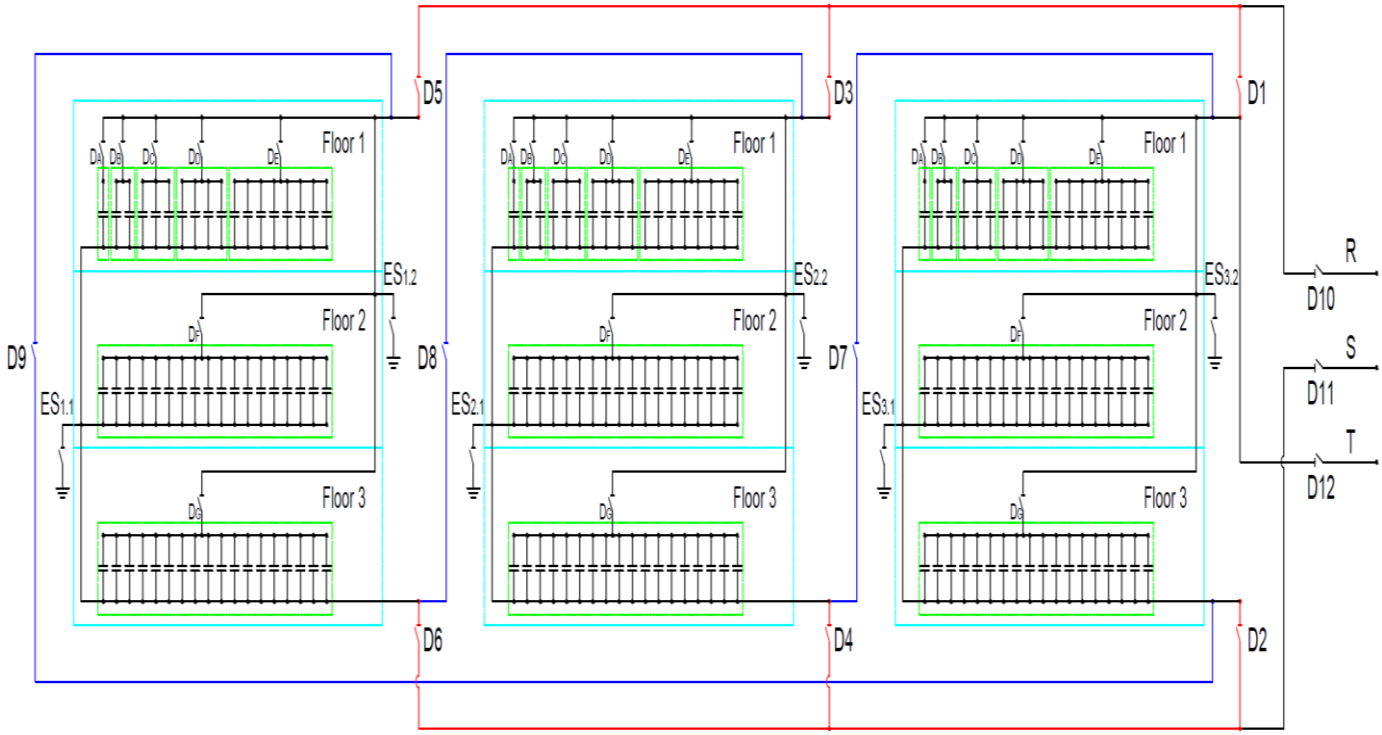

Figure 4

ILLUSTRATIVE SKETCH OF SINGLE-PHASE BANK OF CAPACITOR BANK C(3.3)1

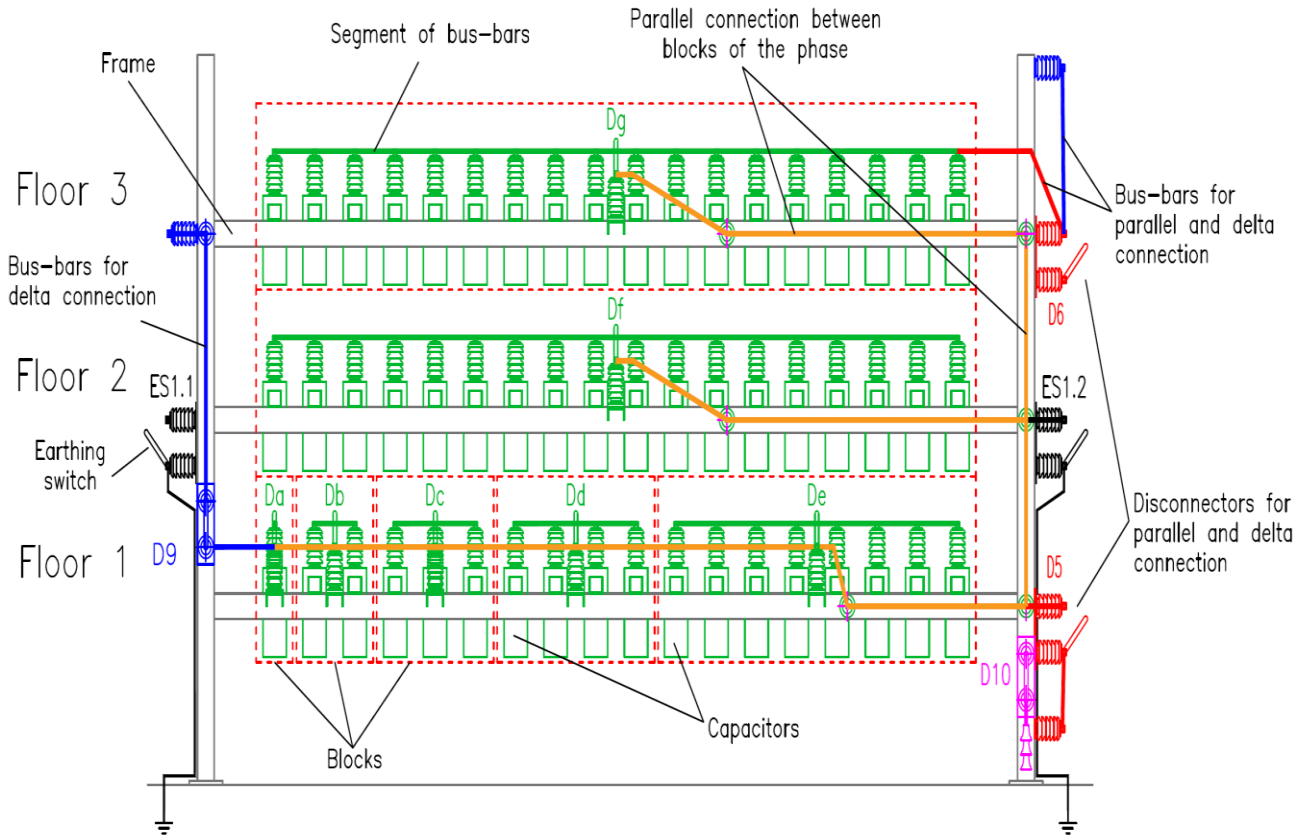

Figure 5a - Side view

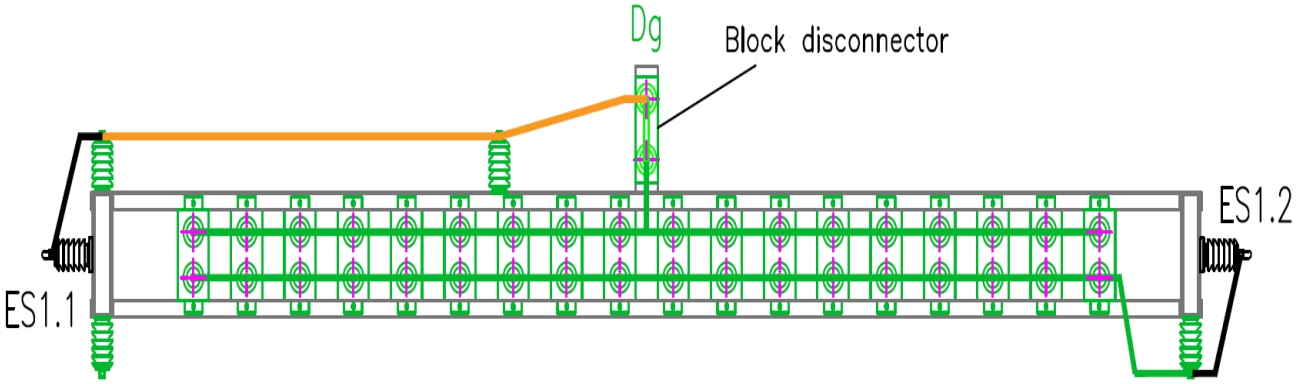

Figure 5b - Top view

Figure 5

BLOCKS AND RELEVANT NUMBER OF CAPACITORS ON EACH FLOOR OF THE CAPACITOR BANK C(3.3)2

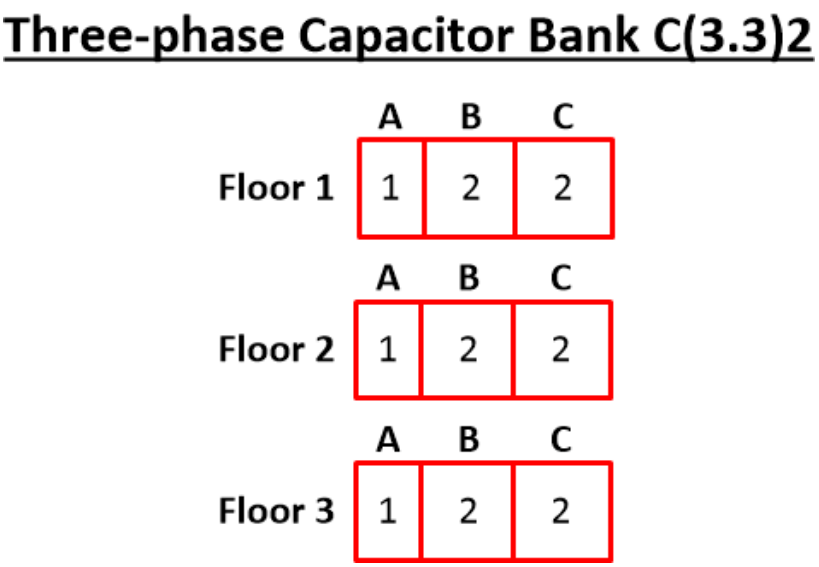

Figure 6

CAPACITOR BANK C(3.3)2 MULTI LINE DIAGRAM