105-15 Specification No. ETI/PSI/75 (10/97)

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

MASTER COPY

Technical Specification
for
25 kV ac 50 Hz Single Phase Series Compensation Equipment

OCTOBER - 1997

RESEARCH DESIGNS & STANDARDS ORGANISATION
LUCKNOW - 226011

REFRENCE COPY

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TECHNICAL SPECIFICATION

FOR

25 kV AC 50 Hz SINGLE PHASE SERIES COMPENSATION EQUIPMENT

RESEARCH DESIGNS & STANDARDS ORGANISATION

MANAK NAGAR, LUCKNOW - 226 011

25 kV AC 50 Hz SINGLE PHASE SERIES COMPENSATION EQUIPMENT

1.0 SCOPE

1.1 This specification covers design, manufacture, supply, erection, testing and commissioning of series compensation equipment for installation on the 25 kV single phase 50 Hz traction overhead conductors for improvement of voltage profile.

1.2 The series compensation equipment shall be installed either at Traction Sub-Station (TSS), at the Sub-sectioning and Paralleling Post (SSP) or Sectioning Post (SP) located along the electrified railway tracks.

1.3 The equipment shall be complete with all the controlgear, protective relays, and accessories needed for its efficient functioning whether specifically mentioned in this specification or not.

1.4 Works to be done by the Purchaser:

Following shall be provided by the Purchaser:

i) Adequate level space at the site of installing capacitor bank for providing the series compensation equipment.

ii) 240V single phase 50 Hz supply at the distribution board inside the existing masonary cubicle of the capacitor bank site.

iii) 24V dc and 110V dc supply at the distribution board inside the site of installing capacitor bank.

iv) Any modification in OHE for connecting the series compensation equipment, including the changes / modification needed at the series compensation site (if any) is included in the scope of the specification. The released material (if any) shall be returned to the purchaser.

1.5 A supervisory control and data acquisition system exists for controlling the supply to OHE through various TSS/SSP/SP along the track. The successful tenderer shall provide facilities for interconnection with the

supervisory remote control equipment to enable remote operation of switchgear and telesignalling of various alarms as mentioned in the specification. RCC equipment and communication cable meant for SCADA can be made available to the successful tenderer for interfacing the RTU of series compensation equipment.

1.6 All other equipment / works including busbars, connectors, jumper connections etc for providing the series compensation scheme is covered in the scope of the works by successful tenderer.

2.0 GOVERNING SPECIFICATIONS.

2.1 The series capacitor bank and its associated items shall unless otherwise specified herein, conform to the latest revision of IEC/Indian Standard specifications, RDSO specifications mentioned below and the Indian Electricity Rules, wherever applicable. In case of any conflict between these standards and the stipulation of the specification, the latter shall prevail.

i) IEC:143 Series capacitors for power systems.

ii) IS:9835 Series capacitors for power systems.

iii) ETI/PSI/167(9/97) 25kV ac 50 Hz single pole out door SF-6 interruptor.

iv) ETI/OHE/16 (1/94) 25kV ac single pole and double pole isolators.

v) IS:2705 Current transformers.

vi) IS:3156 Voltage transformers.

vii) IS:2099 Specification for bushing for alternating voltages above 1000V.

viii) IS:8686 Electrical relays for power system protection.

ix) IS:1243 Direct acting electrical indicating instruments.

2.2 Any deviation from this specification as proposed by the tenderer, intended to improve upon the performance, utility and efficiency of the equipment, shall be considered on merits and in msuch a case full particulars of the deviation with justification should be furnished by the tenderer for consideration.

3.0 TRACTION POWER SUPPLY:

3.1 General Scheme: The single phase, 50 Hz power supply for railway traction at 25 kV is obtained from 220/132/110/66kV three phase grid system through a step down single phase power transformer, the primary winding of which is connected to two of the phases of the three phase effectively earthed transmission line network of the State Electricity Board. In order to reduce the imbalance on the three-phase grid system, the two phases of the three-phase transmission line are tapped in a cyclic order for feeding the successive traction substations(TSS). The distance between adjacent TSS is normally between 50 to 80 kms depending upon density of traffic, gradients in the section and other factors.

3.1.1 One terminal of the 25 kV secondary winding of the traction transformer is connected to the OHE through circuit breakers/interruptors and the other terminal is solidly earthed and connected to the appropriate traction rail(s). The current flows through the OHE, to the locomotives and returns through the rail(s) and earth to the TSS. In sections where booster transformers and return conductor are provided the current returns through these; the traction rail(s) and partly through the earth in the vicinity of the TSS. Approximately midway between two adjacent TSS a dead zone known as 'neutral section' or 'phase break' is provided to separate the different phases. The power fed to the OHE on one side of the TSS is controlled by a feeder circuit breaker while the power fed to the OHE of each track is controlled by an interruptor. In the case of a fault on the OHE, the feeder circuit breaker trips to isolate the faulty OHE. A schematic diagram No. ETI/PSI/702-1(Mod.C) showing the general arrangement at a TSS is at Appendix-1.

3.2 Nature of faults on the OHE:

3.2.1. The OHE is prone to frequent earth faults caused by failure of insulation or by OHE snapping and touching the rail/earth or by a piece of wire dropped by birds which connects the OHE to earth at overline structure/supports or by miscreant activity.

3.2.2 The two sections of OHE fed by different phases are sometimes inadvertantly bridged causing wrong phase coupling.

3.3 Protection Scheme

3.3.1 The faults in the OHE are isolated by the feeder circuit breaker which operates through one or more of the following relays:

i) Distance relay (Mho, lenticular or parallelogram characteristics)

ii) Instantaneous over-current relay and

iii) Wrong phase coupling relay

3.3.2 The faults in the traction transformer are isolated by one of the following relay:

i) Differential relay

ii) IDMT overcurrent relay with instantaneous element for the primary (HV) side.

iii) Instantaneous earth leakage relays on the primary (HV) side as well as on the secondary (LV) side.

iv) IDMT overcurrent relay for the secondary (LV) side.

v) High speed intertripping relay.

vi) Auxiliary relays for transformer faults i.e. Buchholz, excessive winding and oil temperature trip and alarm; and low loil level alarm.

3.3.3 The faults in the shunt capacitor bank are isolated by one of the following relays.

i) Overcurrent relay

ii) Over voltage relay

iii) Under voltage relay and

iv) Neutral current relay

3.3.4 In the event of the 25kV feeder as well as transformer circuit breakers failing to operate under the fault conditions, the 220/132/110/66kV circuit breaker on the primary side of the transformer operates to isolate the fault.

3.4 Short circuit level

3.4.1 The fault level for different grid supply voltages based on a three phase symmetrical short circuit fault is between 1000 MVA and 10,000 MVA depending upon the proximity of the traction sub-station to the generating station. The level of the short circuit on the 25kV side for a fault in the vicinity of substation could be around 100-150 MVA.

3.5 Nature of load:

3.5.1 The traction load is of frequent and rapidly varying nature and fluctuates between no load and overloads. The load cycle varies from day to day due to non-uniform pattern of traffic.

3.5.2 An ac electric locomotive is fitted with single phase bridge connected silicon rectifier with smoothing reactor for conversion of a.c. to d.c. for feeding the dc traction motors. The ripple current is in the region of 25 to 40%, which introduces harmonics in the 25kv power supply. Indian Railways plan to introduce thyristor controlled locomotives which would also introduce harmonics in the system. The typical percentages of current harmonics present in the traction current with the diode rectifier and the thyristor locomotive are as follows:

	With diode rectifier	With thyristor.
3rd harmonic (150 Hz)	15%	23%
5th harmonic (250 Hz)	6%	14%
7th harmonic (350 Hz)	4%	10%

3.5.3 The average power factor of electric locomotive and multiple unit trains generally varies between 0.7 and 0.8 lagging without compensation.

3.5.4 For improving power factor, fixed shunt capacitor bank with 13% series reactor are also installed at some traction substations, the net KVAR rating of which is generally of the order of 2500 KVAR.

3.6 Electrical parameters:

3.6.1 The OHE is made up of a standard cadmium copper catenary of 65 sq.mm cross section and a grooved copper contact

wire of 107 sq.mm cross section, making up a total of 150 sq.mm copper equivalent. The impedance values are generally taken as under:

i)	Single track OHE without return conductor.	0.41 < 70 deg. Ohm/km.
ii)	Double track OHE without return conductor.	0.24 < 70 deg. Ohm/km.
iii)	Single track OHE with return conductor.	0.70 < 70 deg. Ohm/km.
iv)	Double track OHE with return conductor.	0.43 < 70 deg. Ohm/km.
v)	Percentage impedance of traction transformer (12.5 MVA) at 26.7 kV.	(10 +/- 0.5) %
vi)	Percentage impedance of traction transformer (21.6 MVA) at 27 kV.	(12 +/- 0.5) %

3.7 Surges:

From various tests conducted on the traction overhead equipment, it has been established that short duration switching surges are generated due to various switching operations. These surges are in the range of 60 to 70 kVp. However, in cases of shunt capacitors installed at traction substations, surges of the order of 120 to 130 kVp have been recorded during switching on / off of the shunt capacitor circuit breaker.

4.0 SERVICE AND ENVIRONMENTAL CONDITIONS:

i)	Maximum ambient air temperature	- 45 degree C
ii)	Minimum ambient air temperature	- 0 degree C
iii)	Average ambient air temperature over a period of 24 hours.	- 35 degree C
iv)	Maximum relative humidity	- 100 %
v)	Annual rainfall.	- Ranging from 1750 to 6250 mm.

vi) Number of thunderstrom days per annum. – 85 days(Maximum)

vii) Number of duststrom days per annum. – 35 days(Maximum)

viii) Number of rainy days per annum. – 120 days(Maximum)

ix) Maximum basic wind pressure. – 200 kg/sq.m.

x) Altitude. – Not exceeding 1000 m

xi) Pollution level – Heavily polluted (IS:2099)

The equipment would be subject to vibrations on account of trains running on nearby railway tracks. The amplitude of these vibrations which occur with rapidly varying time periods in the range of 15 ms to 70 ms lies in the range of 30 to 150 micron at present, with the instantaneous peak going upto 350 micron.

5.0 PARTICULARS OF THE SYSTEM:

i)	System	25kV single phase 50 Hz ac traction system.
ii)	Nominal system voltage –	25 kV subject to variation from 19 kV to 27.5 kv – Occasionally touching 30 kV.
iii)	Rated frequency	50 Hz +/– 3%
iv)	Rated voltage class	52 kV
v)	Rated insulation level –	
	(a) Rated lightning impulse withstand voltage.	250 kV (peak)
	(b) Rated one minute power frequency withstand voltage (Dry/wet)	95 kV (rms)

6.0 TECHNICAL SPECIFICATION:

6.1 Load pattern:

The compensation scheme shall be designed keeping in view the present as well as the future load pattern. The load pattern of the section in which series compensation is to be applied shall be furnished by the purchaser.

6.2 The series compensation equipment shall be designed such that compensation is available on both up and down lines under normal working conditions as well as under conditions of extended feed. The compensation shall also be adequate when either up or down line is isolated under emergency conditions. In order to meet this requirement the series compensation equipment shall be suitably designed for both up and down lines.

6.3 The compensation scheme, shall be such that a minimum voltage of 20 kV is always available at the far end under normal as well as under extended feed condition during all forseeable OHE configurations, assuming a constant voltage of 132 kV / 220 kV (as the case may be) on the primary side of the traction transformer. The tenderer shall ensure that under no circumstance a voltage greater than 27.5 kV is obtained at any point on the OHE.

6.4 The compensation of the OHE reactance upto the point of installation of series capacitors shall be restricted to not more than 80% in case of Capacitor Bank installed at SP/SSP.

In case of compensation at TSS, the maximum limit of compensation shall be restricted to 80% of the Transformer + source Grid reactance.

6.5 The comoensation scheme shall be provided across conventional neutral section/short neutral section or in the neutral side of the TSS Power Transformer.

6.6 <u>Basic Scheme:</u>

A basic scheme incorporating medium speed re-insertion and using single gap for protection is shown at Appendix-2 for guidance of the tenderer.

6.7 The tenderer shall ensure that adequate arrangement is provided to -

i) Discharge the trapped charge of the capacitor

ii) To limit the discharge current through spark gap and bypass breaker as also to dampen the oscilations (if any).

iii) Avoid building up of sub-harmonic oscilations due to ferro-resonance.

iv) Preclude possibility of resonance and increase in short circuit current at any point on the OHE beyond 8 kA (rms) under any conditions.

v) Protect the existing equipment from any adverse effect which the series compensation might cause by way of over voltage, switching surges etc.

6.8 Rating of series compensation equipment:

6.8.1 Series capacitor:

The series capacitor shall be designed generally in accordance with IEC:143.

6.8.2 The voiltage rating of the capacitor shall be such that -

i) No spark over results due to normal switching surges.

ii) Gap spark over and bypass of the capacitor is ensured under all fault conditions.

iii) Withstand voltage across the capacitor under maximum through load current under all possible conditions is below the voltage for which the capacitor is rated, with adequate safety margins.

iv) The short time withstand voltage of the capacitor is at least above 3.85 p.u.

6.8.3 The tenderer shall ensure that the voltage rating of the capacitor is arrived at after considering the switching surges, the characteristic of the spark gap, the through current at the location of compensation scheme, fault current, harmonics and any other relevant factor after taking adequate safety margins. A detailed calculation with graphs (if any) shall be furnished by the tenderers along with the offer.

6.8.4 The current rating of the capacitor shall be such that -

i) It can carry maximum possible through load current at the series compensation location.

ii) It can withstand fault current with fault at the capacitor terminal until the spark gap flashover/bypass.

iii) Harmonics present in the system shall be actually measured at site and adequate correction to the current ratings done accordingly.

iv) Any other relevant factor is taken into account with adequate safety margins.

6.8.5 Tenderer shall furnish full details of measurements, calculation including graphs (if any) showing calculations to arrive at the current rating of the capacitor along with his offer.

6.9 Spark gap:

6.9.1 This being a critical component of the scheme, its design is of paramount importance. The tenderer should note that faults in the IR traction system are frequent. The spark gap should therefore be such that -

i) It requires no adjustment or maintenance for 10 years or 5000 operations, whichever is later.

ii) Its characteristic is uniform and stable even after long usage and under varying environmental conditions. The tenderer shall therefore provide an open ventilated type trigger spark gap.

iii) The spark gap flashover time shall be around 5 ms from the time of occurence of a fault.

iv) The deionisation time shall be very small and

v) Arc quenching after operation of bypass switch shall be quick to enable spark gap to be in readiness for its next operation.

6.9.2 Tenderer shall furnish full technical particulars of the spark gap and its associated circuitary which he proposes to use, in his offer.

6.10 Bypass switch

6.10.1 The bypass switch shall be suitable for repeated and quick closure with heavy capacitor discharge current besides being capable of inserting the series capacitor in the system (opening) without any restrikes. The bypass switch shall be a vacuum switch capable of at least 10000 operations without any maintenance or replacement of parts.

6.10.2 Tenderer shall furnish full technical details of the bypass switch he proposes to use in his offer along with full documentary evidence of its rating.

6.11 Coordination of timings of spark gap flash over, bypass switch operation, and reinsertion of capacitor with operating timings of feeder circuit breaker and protective relays:

6.11.1 The scheme offered shall ensure that –

(i) The spark gap flash over timing and closure timing of bypass switch is coordinated with the short time withstand voltage of capacitor with adequate safety margin. Spark gap timings of 5 ms and bypass contactors timings of 10 ms after the spark over are considered preferable.

(ii) The reinsertion time of capacitor shall be quick once the OHE is ascertained as live and healthy. The reinsertion time shall be coordinated in such a way that the locomotive circuit breaker does not trip in the intervening period of no compensation due to under voltage.

(iii) The reinsertion should take place only after the OHE has been energised and found to be healthy. Suitable sensing mechanism through PT or any other suitable means shall be designed and incorporated by the tenderer.

(iv) The deionisation time of spark gap shall be small enough to ensure that the spark gap is ready for its duty before the capacitor is reinserted. The withstand voltage of the spark gap before reinsertion is important from the point of view of short time withstand voltage of the capacitor and should be properly coordinated to arrive at the appropriate value.

6.12 Effect on existing protection scheme:

Some of the existing protection scheme particularly the distance protection scheme using YCG-14/YTG-14/AZ-1114 mho relay may be effected by the presence of lumped series capacitor. The tenderer shall take particular note of this and shall provide detailed calculations in his offer with the suggested setting of the existing relay to prove that the existing protection scheme shall function properly even after the introduction of the series compensation scheme.

Tenderer should also take note of the other protection scheme already existing and ensure that the protection is not vitiated by presence of the series compensation scheme.

6.13 Protection arrangement:

6.13.1 Following relays shall be provided for the protection of the capacitor:

(i) Overcurrent relay suitably set considering the overcurrent rating of the capacitor.

(ii) Unbalance current relay for protection of the capacitor due to internal faults.

(iii) Sub-harmonic relay to protect the capacitors from over voltage due to development of ferro-resonance.

(iv) Earth fault relay to protect the capacitors from platform to earth flashovers.

(v) Over voltage relay to protect the capacitor from sustained over voltage.

(vi) Spark gap relay to initiate closure of bypass switch on spark gap flashover.

(vii) Any other relay considered necessary by the tenderer.

6.13.2 Full details of the protection scheme proposed by the tenderer along with the settings of the relays shall be submitted to the purchaser/DG/TI/RDSO, Lucknow giving full calculations and technical particulars for approval.

6.13.3 The series compensation equipment shall also be adequately protected against lightning surges, switching surges and over voltages.

7.0 GENERAL ARRANGEMENT:

7.1 The series compensation equipment shall be of outdoor type mounted on steel structure for connection to the 25 kV OHE generally as per the diagram placed at Appendix 2 & 3.

7.2 The arrangement shall enable bypassing of the capacitor bank whenever the bank is faulty with least disruption to train operations.

7.3 Capacitor bank shall consist of a groups of individual capacitor units connected in series parallel combination to deliver the rated output at nominal rated system voltage and rated frequency. The units shall be provided with internal fuse to protect them from internal faults.

The number of parallel element in each series group shall not be less than 10 and number of series groups shall not be less than 4. The capacitor bank shall be supplied complete with mounting steel rack assembly hot dip galvanised, inter connection between units, insulators, busbar, earthing lugs, terminal connection including jumpers etc. for connection to the OHE.

8.0 MOUNTING ARRANGEMENT:

8.1 The capacitor bank alongwith the associated equipment for protection, damping resistor/reactor, PT, CT etc. shall be suitable for mounting on steel gantry, hot dip galvanised, in line with the existing arrangement. Alternatively the capacitor bank with associated equipment may be mounted on, concerete plinth in suitable base frames, rack insulators and other hardware etc. There shall be a metal enclosure with lockable/interlock doors for the safety of the personnel.

8.2 The successful tender/manufacturer shall provide a fibre glass roof over the capacitor bank installation to protect it from direct exposure to the sun.

8.3 A suitable enclosure shall be provided (if required) for the capacitor bank to avoid faults on account of birds.

9.0 CONTROL AND RELAY PANEL:

9.1 A control and relay panel housing various relays, switches, and LED/LCD digital display indicating meters etc. shall be supplied along with the series compensation equipment. The control & relay panel shall be installed in the masonry control cubicle inside the TSS/SSP/SP. The control & relay panel shall be vertical mounting, self-supporting steel construction type stove-enamelled painting shall be done on the panel. The colour of the panel shall be "light admiralty grey", conforming to IS: 5 Shade-697 on the exterior and white on the interior surfaces. The overall dimensions of the control panel shall not exceed 800 (W) x 500 (Depth) x 2000 (Height). Due to availability of limited space in the masonry control cubicle of SSP/SP, the back of the control panel shall be placed close to the wall and only front door opening shall be possible. The control switches, instruments, relays, indicating lamps etc. shall be mounted flush on the front door and the layout of wiring, equipments, terminal blocks, test blocks, fuses and any other equipment/component inside the panel shall be such that free access is possible for ease of maintenance.

9.2 The control & relay panel shall be fabricated from sheet steel of uniform gauge, and of at least 2 mm thickness for front, base frame and door frame and of 1.6 mm thickness for side walls, back wall and roof. Suitable cable entries shall be provided from the bottom of the control panel for which proper opening shall be provided on the bottom plate. The control panel shall be suitable for erection flush with the concrete floor by evenly spaced grouting bolts projecting through the base channel of its frame. The control panel shall be dust, vermin and moisture-proof. The overall size of the control panel shall be subject to the approval of Purchaser/DG/TI/RDSO, Lucknow. Successful tenderer shall furnish full technical details including wiring diagram of control and relay panel to Purchaser/DG/TI/RDSO, Lucknow for approval.

9.3 Instruments:

A switch-board type semiflush mounted Digital, LCs/LED type ammeter of suitable range shall be provided for measurement of capacitor current. It will be of class-A industrial grade accuracy. Its circuits shall be capable of withstanding 20% overload for 8 hours. It will be subjected to a high voltage test of 2 kV rms for one minute. The instrument will be with dust-tight case.

9.4 A two-position (local)/remote) change-over switch for the control of bypass switch and interruptor (if any) shall be provided on the control panel, alongwith a suitable spring return type control switch having three positions - ON / OFF / Neutral. The switch will have a sequence device to prevent two successive movements to the same position. Following indication lamps shall also be provided.

(i) Bypass switch (and any other interruptor etc) 'closed'. - Red

(ii) Bypass switch (and any other interruptor etc) 'Open'. - Green

(iii) 110V dc auxiliary supply healthy. - Yellow

Low voltage, screw type, lamps suitable for 110V dc supply shall be used. All indicating lamps shall be replaceable from the front of the panel. Lamps shall also be provided with screwed type lamp covers made from transluscent unbreakable material to diffuse light.

9.5 Mimic diagram:

9.5.1 The scheme of connections at TSS/SSP/SP showing the incoming isolators, capacitor bank, bypass switch etc shall be represented by a single line mimic diagram on the control panel. The colour of the mimic diagram will be golden yellow to shade 356 of IS:5. Automatic semaphore relay shall be incorporated in the mimic diagram to indicate the position of the bypass switch and interruptors (if any). Position of 25 kV manually operated isolators (if any). Position of 25kV manually operated isolators (if any) shall be represented on the mimic diagram by manually operated semaphores. Push buttons and yellow indication lamps shall be provided on the control panel to monitor the availability of 110 V dc supply on the panel, and the continuity of auxiliary supply for the bypass breaker and interruptor (if any).

9.6 Annunciation windows, suitable for operation on 110V dc supply shall be provided on the front top side of the control panel for giving various fault indications for operation of the relays. Audible alarm either by hooter or bell operated on 110V dc shall also be provided. The annunciation windows shall be back connected with dust tight case, suitable for semi-flush mounting. The alarm-cancelling, visual-resetting and annunciation-testing buttons shall be mounted on the control panel at a convenient height.

9.7 The bypass switch and interruptor of the compensation scheme shall be suitable for operation by remote control. Suitable terminals should be provided on terminal block duly wired for telesignal and telecommand. Terminals for the following telesignals and telecommands shall also be provided:

(i) A telesignals for supervision of secondary fuse of voltage transformer (PT).

(ii) Two telecommand one for closing and one for opening operation of capacitor bypass switch and any other interruptor etc. (if provided).

(iii) A telesignal to indicate 'open' position of bypass switch and any other interruptor etc. (if provided).

(iv) A telesignal to indicate 'close' position of bypass switch or any other interruptor etc. (if provided).

(v) An alarm telesignal for capacitor fault

(vi) A spare telesignal

9.8 Suitable terminal blocks including testing terminal shall be mounted conveniently inside the control panel. The current rating of the contacts shall be 30 Amps. continuous at 110V dc. The current terminals shall be provided with short circuiting links or other suitable device. The potential terminals shall be housed in narrow recesses of the moulded insulation block to prevent accidental short circuit. Terminals on the blocks shall be stud type for crimped terminal/lugs, securely tightened with nuts and spring washers. AC and DC terminals shall be separated. Each terminal shall be completely shrouded.

9.9 Relays:

The protective relays shall be mounted on the control panel and shall be semi-flush mounting type with back connections and provided with dust-proof covers and test plug for setondary injection tests. The relays shall be of approved make.

9.10 All panel wiring shall be done with switch-board type 650V grade PVC insulated single core stranded tinned annealed copper conductors. AC and DC circuits shall be kept separate.

9.11 Suitable space heaters to operate off 240V, single phase, ac supply with 'ON' and 'OFF' switches shall be provided inside the control panel to prevent condensation of moisture in humid weather.

9.12 One combined three-pin switch plug, 5 Amps rating shall be provided inside the panel for using 240V hand lamp.

9.13 Wherever required, only HRC type catridge fuses of appropriate rating shall be used in the control panel at easily accessible places.

10. CURRENT TRANSFORMER AND POTENTIAL TRANSFORMER:

10.1 Suitable current and voltage transformers as per IS 2705 & IS 3158 respectively of the required VA rating shall only be used by the successful tenderer.

11. EARTHING:

11.1 Earthing arrangements shall be provided in accordance with IS:3043. Indian Standards Code of Practice for Earthing and Code of Bonding and earthing issued by RDSO.

12. GALVANISATION:

12.1 All steel structure exposed to weather shall be hot dip galvanised as per RDSO specification No. ETI/OHE/13.

13. TESTS:

13.1 All the type and routine tests shall be conducted on the series compensation equipment as per relevant specification by representative of DG/TI/RDSO, Lucknow. The representative of DG/TI/RDSO, Lucknow shall however, be free to conduct any additional test considered necessary by him to ascertain the suitability of the offered equipment. The tenderer shall provide all testing facility free of cost for all such additional tests.

13.2 Tests on Control Panel:

The following checks and tests shall be carried out on the control panel:

(i) Visual checks:

General check of control board in respect of construction, wiring, provision of various equipments/relay etc.

(ii) Operation tests:

Operation tests on all equipments and switches, and tests to prove correctness of wiring of various circuits including indications, alarms, operation of relays and annunciation etc.

(iii) High voltage withstand tests:;

Voltage tests on the panels with all equipments and wiring for a withstand voltage of 2000V(rms) to earth for one minute.

(iv) Insulation resistance tests:

Measurement of insulation resistance of the complete panel wiring and circuit with all equipments mounted on the panel by using 1000 V megger.

13.3 Test on Capacitor Units and Capacitor Bank:

The tests shall generally be in accordance with IEC:143 and IEC:871 (latest version).

13.4 Tests on Spark Gap: The spark gap and its associated circuitry shall be subjected to:

(i) Visual tests.

(ii) Operation tests : To see that the associated circuitry function as provided. Successful tenderer shall furnish test reports of other destructive tests for scrutiny and approval by DG/TI/RDSO, Lucknow.

(iii) Any other test considered necessary by representative of DG/TI/RDSO, Lucknow.

13.5 Test on bypass switch:

(i) Dielectric tests

(ii) Visual check

(iii) Operation test and

(iv) Any other tests considered necessary by representative of DG/TI/RDSO, Lucknow.

13.6 Test on relays, PT & CT:The tests on PT/CT shall be generally in accordance with IS 3156 and IS 2705. Relays shall be subjected to functional tests and visual checks. For other tests successful tenderer shall submit the reports to DG/TI/RDSO, Lucknow.

13.7 Pre-commissioning tests:

In addition to the above tests, following field tests shall be conducted on the series compensation equipment before commissioning:

(i) Measurement of OHE voltage and current with and without train load.

(ii) Measurement of voltage across the series capacitor under load conditions and fault conditions.

(iii) Measurement of surges when the locomotive negotiates the over lap opposite the TSS/SSP/SP provided with series compensation.

(iv) Actual fault tests to prove effectiveness of spark gap and bypass switch operation including time measurements of spark gap operation and bypass switch operation.

(v) Tests to ascertain effectiveness of the protective system.

(vi) Any other test considered necessary by the purchaser to prove the effectiveness of the scheme.

14. TECHNICAL DATA AND DRAWINGS:

14.1 The tenderer shall be required to furnish detailed calculation, graph, tables etc for voltage profile of the section after commissioning of series capacitor banks system. Detailed transient calculation and voltage simulated profile shall be submitted by the tenerer to confirm that sub-harmonic transients do not occur for the compensation level chosen by the tenderer.

14.2 The tenderer shall furnish guaranteed performance data, technical and other particulars for the equipments offered in the proforma attached as Annexure-A. Technical details of the protection employed together with detailed calculation for the ratings of the equipment shall also be furnished with the tender. If the tenderer deviates from the provision of these clauses, he shall furnish his detailed remarks.

14.3 The successful tenderer shall be required to submit detailed dimensioned drawings for approval and shall also furnish six copies of the same alongwith two copies of transparent reproducible prints, as per Railways Standards in sizes of 210 mm x 297 mm or any integral multiple thereof.

14.4 The successful tenderer will also be required to submit six copies of the technical booklets, eretion, operation and maintenance manuals and tests reports to the indentor and one copy each to the consignee(s).

15. ADDITIONAL PARTICULARS:

The tenderer shall visit the traction substation, SSP and SP location, if necessary, and collect any additional data/details required for the design of the compensation scheme. It would be the responsibility of the tenderer to visualise the problems and understand the system conditions before evolving a suitable design.

16. ERECTION, TESTING AND COMMISSIONING:

The successful tenderer shall be responsible for supervising erection of capacitor equipment, circuit breaker, isolator, busbars, instrument transformers and other associated equipments and shall carry out precommissioning tests and commission them to the satisfaction of the Purchaser.

In case there are any changes/modifications/replacement needed in the existing protection scheme, the Tenderer shall change the same free of cost and shall be considered to be well within the scope of the work.

17.0 WARRANTY:

The tenderer shall submit warranty for successful working of the system and failure of any equipment due to defective design, for a period of six years from the date of delivery or for a period of 5 years from the date of commissioning, whichever is earlier.

18.0 SPARES:

The tenderer shall furnish the list of maintenance spares required, if any, which may be required to commission the system in the least possible time, in case of a failure.

19.9 MAINTENANCE MANUALS:

The successful tenderer shall supply 15 copies of Maintenance Manuals including spare parts list and catalogue numbers.

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Annexure to Specification
No. ETI/PSI/75(10/97)

SCHEDULE OF GUARANTEED PERFORMANCE DATA, TECHNICAL AND OTHER PARTICULARS.

SNo.	Description	Unit of measurement
1	2	3
A.	CAPACITOR EQUIPMENT	
1.	Maker's name.	
2.	Country of manufacture.	
3.	Manufacturer's type designation.	
4.	Location of capacitor bank (outdoor/indoor)	
5.	Nominal rated voltage	kV
6.	Each capacitor unit:	
	(a) Rated output	kVAr
	(b) Rated voltage	kV
	(c) Rated current	Amp
	(d) Rated capacitance	Microfarad
	(e) Rated frequency	Hz
	(f) Shot-time withstand voltage	kV
	(g) Limits of variation of output capacity	%
	(h) Upper limit of temperature category.	
	(i) Resistance of the discharge resistor if built-in	
	(j) Rating of Internal fuses (Please furnish graph)	
	(k) Number of parallel elements	
	(l) Number of series groups	
	(m) Type of fuse on individual capacitor unit.	

n) Rating of the external fuse (if provided)

(o) Reference to the time/current characteristics of the fuses used.

7. Complete series capacitor bank:

(a)	Rated output	kVAr
(b)	Rated voltage	kV
(c)	Rated current.	Amp
(d)	Reactance.	Ohm
(e)	Permissible current for 15 mts.	Amp
(f)	Limiting voltage.	
(g)	Number of series units	
(h)	Number of parallel units.	
(i)	Momentary over voltage withstand	kV
(j)	Short time overload (indicate the current and duration)	
(k)	Maximum voltage (rms) which the capacitor bank can withstand	
	(a) Continuously	kV
	(b) For one minute	kV

8. Basic insulation level of unit:

(a)	Power frequency voltage withstand.	kV (rms)
(b)	1.2/50 microsecond impulse withstand voltage.	kV(peak)

9. Basic insulation level of complete capacitor bank:

(a)	Power frequency voltage withstand	kV(rms)
(b)	1.2/50 microsecond impulse withstand voltage.	kV(peak)

10. Transient current withstand capacity of capacitor bank. kA

11. Constructional details of capacitor unit:

(i) Dielectric material

(ii) Foil material

(iii) Impregnating liquid used and its properties.

(iv) Discharge resistors

(v) Internal fuses

12. Capacitor loss per kVAr at rat ed voltage and frequency. Watts.

13. Internal fuse:

(i) Type of internal fuse elements of capacitor units.

(ii) Length of use element mm

(iii) Cross section of the fuse element Sq.mm

(iv) Circumference of use element mm

(v) I^2t characteristics

(vi) Time factor(s) of fuse element.

14. Details of discharge device:

(i) Type

(ii) Location

(iii) Time interval between deenergisation and renergisation minute

(iv) Residual voltage after an interval of 5 minutes of denergisation. volts

15. Bushings:

(i) Maker's name

(ii) Governing specification.

(iii) Wet 1-minute power frequency voltage kV(rms)

(iv) Impulse voltage withstand 1.2/50 microsecond full wave. kV(peak)

(v) Creepage distance in air. mm

(vi) No. of bushings in each unit No.

16. Spark gap:

(i) Type of spark gap

(a) Open ventilated/sealed.

(b) With trigger/without trigger

(ii) Make

(iii) No. of permissible spark over at maximum through fault current without adjustment. — Nos.

(iv) Life (No. of spark overs at maximum through fault current before replacement). — Nos.

(v) Spark over voltage. — kV

(vi) Time to spark from occurance of a fault.

(a) At maximum fault current — ms

(b) At minimum fault current — ms

(vii) Time to regain 80% of its dielectric strength after flash over at maximum fault current. (Please furnish characteristic curve).

(viii) Error of discharge voltage — %

(ix) Current impulse withstand — kA (peak)

(Please furnish characteristic curves in regard to withstand values & deionisation time).

17. Overall dimensions:

(i) Capacitor unit.

(ii) Complete capacitor bank.

18. Weight of each capacitor unit. — kg

19. Weight of the complete capacitor bank. — kg

B- CONTROL AND RELAY PANEL

1. Name of manufacturer and address.

2. Overall dimensions.

L- mm
W- mm
H- mm

3. (i) Colour of the panel.
(ii) Colour of the mimic.

4. Details of switches provided and their make.

5. Annunciations provided.

6. Size of wires used for:

(i) Control circuit
(ii) Indication circuit
(iii) General wiring
(iv) PT circuits
(v) CT circuits

7. Method of cable entry.

8. Details of instruments, if any, provided.

9. Details of CT:

(a) Rated transformation ration
(b) Rated burden
(c) Accuracy class
(d) Rated short time current
(e) Insulation level.

10. Details of PT:

(a) Rated primary and secondary voltage
(b) Rated burden
(c) Accuracy class
(d) Insulation level
(e) Type of relays.

11. Details of protective relays.	Type & make	Setting range
(a) Over load protection		
(b) Over voltage protection		
(c) Sub-harmonic protection		
(d) Unbalance protection		
(e) Any other protection envisaged. (Please furnish characteristics).		

C- CURRENT LIMITING REACTORS (if provided)

(i)	Rated voltage	–	kV
(ii)	Rated frequency	–	Hz
(iii)	Inductance	–	mH
(iv)	Rated current	–	A
(v)	Short time overload		(indicate current and duration)
(vi)	Peak current withstand value	–	kA(peak)
(vii)	Short time rating for 3 seconds	–	kA
(viii)	Overall dimensions	–	mm
(ix)	Total weight	–	kg

D- SUB-HARMONIC SUPRESSING DEVICE (if provided)

(i)	Type		
(ii)	Make		
(iii)	Rated voltage	–	V
(iv)	Exciting current	–	A
(v)	Resistance of built-in resistor	–	Ohm

(vi) Details of built-in protential transformer:

(a)	Primary voltage	V
(b)	Secondary voltage	V
(c)	Secondary burden	VA
(d)	Class of accuracy.	

E- BY-PASS VACUUM CIRCUIT BREAKER/CONTACTOR:

(i)	Make	
(ii)	Type	
(iii)	Rated current	A
(iv)	Rated closing current	kA(peak)
(v)	Rated breaking current	kA
(vi)	Rated closing time	ms
(vii)	Rated break time	ms
(viii)	No. of close/open operations one before change in contacts/ any other parts.	Nos.

F- DETAILS OF SCHEME OFFERED:

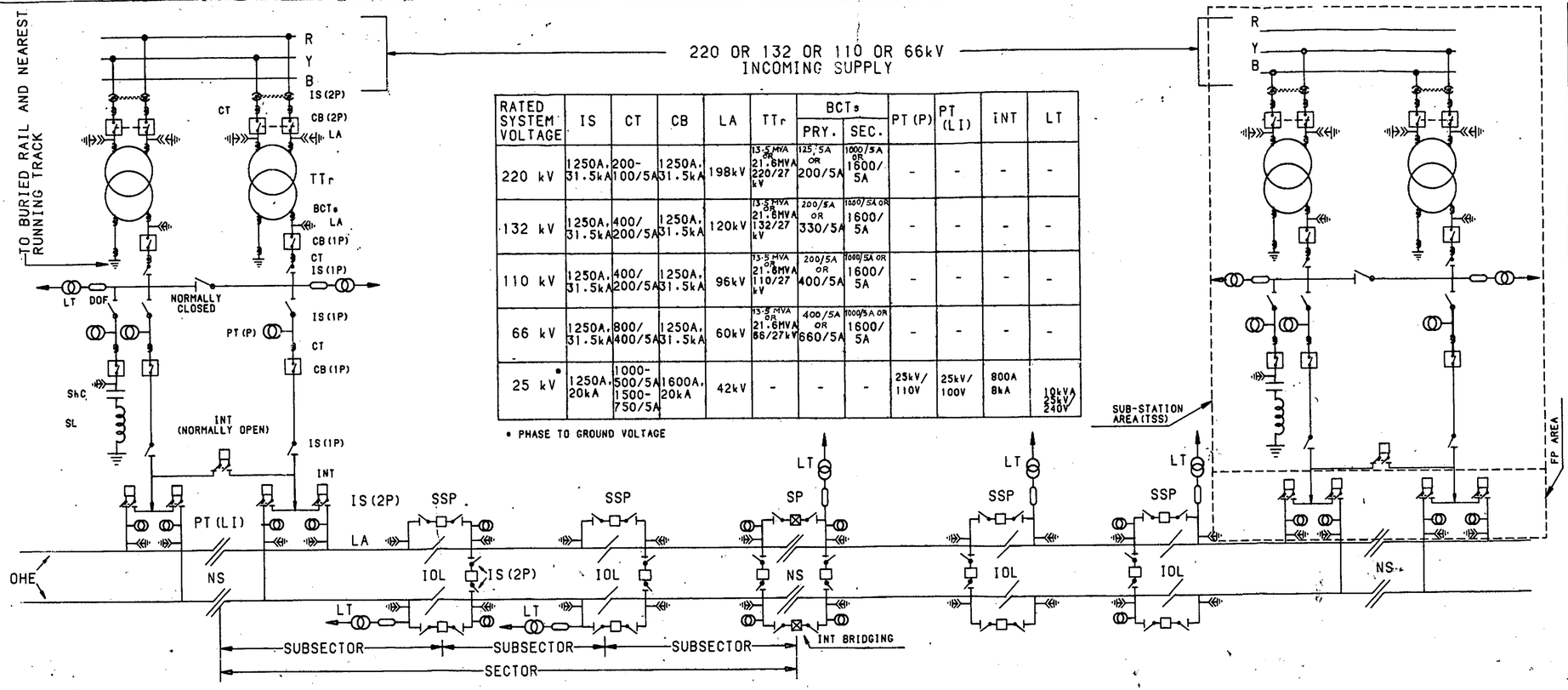
(i) The sequence of operations leading to the closure of the bypass breaker under a through fault.

(ii) Sequence of events leading to re-insertion of the capactor bank on reclosure of the capacitor bank on reclosure through auto reclosure scheme on occurence of a fault.

(iii) Calculations to show improved voltage profile after provision of series capacitor.

(iv) Calculation/graphs to show effect on existing protector schemes.

(Please furnish a detailed schematic & write-up wherever required).



RATED SYSTEM VOLTAGE	IS	CT	CB	LA	TTr	BCTs PRY.	BCTs SEC.	PT (P)	PT (LI)	INT	LT
220 kV	1250A, 31.5kA	200-100/5A	1250A, 31.5kA	198kV	13.5 MVA OR 21.6MVA 220/27 kV	125/5A OR 200/5A	1000/5A OR 1600/5A	-	-	-	-
132 kV	1250A, 31.5kA	400/200/5A	1250A, 31.5kA	120kV	13.5 MVA OR 21.6MVA 132/27 kV	200/5A OR 330/5A	1000/5A OR 1600/5A	-	-	-	-
110 kV	1250A, 31.5kA	400/200/5A	1250A, 31.5kA	96kV	13.5 MVA OR 21.6MVA 110/27 kV	200/5A OR 400/5A	1000/5A OR 1600/5A	-	-	-	-
66 kV	1250A, 31.5kA	800/400/5A	1250A, 31.5kA	60kV	13.5 MVA OR 21.6MVA 66/27kV	400/5A OR 660/5A	1000/5A OR 1600/5A	-	-	-	-
25 kV *	1250A, 20kA	1000-500/5A 1500-750/5A	1600A, 20kA	42kV	-	-	-	25kV/ 110V	25kV/ 100V	800A 8kA	10kVA 25kV/ 240V

* PHASE TO GROUND VOLTAGE

NOTE:-

1. 25 kV SHUNT CAPACITOR BANK COMPLETE WITH CONTROL GEAR, PROTECTION RELAYS, SERIES REACTOR AND ACCESSORIES NECESSARY FOR ITS EFFICIENT OPERATION SHALL ALSO NEED TO BE PROVIDED AT THE RAILWAYS TRACTION SUB-STATION (TSS) WHERE IT IS SPECIFICALLY MENTIONED BY THE PURCHASER.

2. FOR DETAILS OF EQUIPMENT AND ITS RATING ETC., LATEST EQUIPMENT SPECIFICATIONS AND THE SUB-STATION LAYOUT DRAWING SUPPLIED BY PURCHASER MAY BE REFERRED.

3. THE RATING OF BUSHING CTs WOULD VARY ACCORDING TO THE TRACTION TRANSFORMER CAPACITY.

LEGEND :-

IS	ISOLATOR	LT	AUXILIARY TRANSFORMER.
CT	CURRENT TRANSFORMER	ShC	SHUNT CAPACITOR
CB	CIRCUIT BREAKER	SL	SERIES REACTOR
LA	LIGHTNING ARRESTER	FP	FEEDING POST
BCTs	BUSHING CTs	SSP	SUB-SECTIONING AND PARALLELING POST.
TTr	TRACTION TRANSFORMER	SP	SECTIONING POST
PT(P)	POTENTIAL TRANSFORMER (PROTECTION TYPE)	NS	NEUTRAL SECTION
PT(LI)	POTENTIAL TRANSFORMER (LINE INDICATION TYPE)	IOL	INSULATED OVERLAP
INT	INTERRUPTOR	DOF	DROP OUT FUSE SWITCH
		1P	SINGLE POLE
		2P	DOUBLE POLE

THIS DRAWING SUPERSEDES DRG. No. ETI/PSI/702 AND 707.

GENERAL SCHEME OF SUPPLY FOR 25 kV, 50 Hz SINGLE PHASE TRACTION SYSTEM

JD/TI 25.8.92

ADE/PSI 25.8.92

REF :-

CROSS REF :-

DT.	MOD.	NATURE OF MOD.	INITIAL
12.09.91	A	PROGRAM RATING OF TRANSFORMER AND CT RATIO CORRECTED.	
25.8.92	B	PANTOGRAPH ADDED	
20.8.94	C	RATING OF 13.5MVA TRANSFORMER ADDED	

R.D.S.O

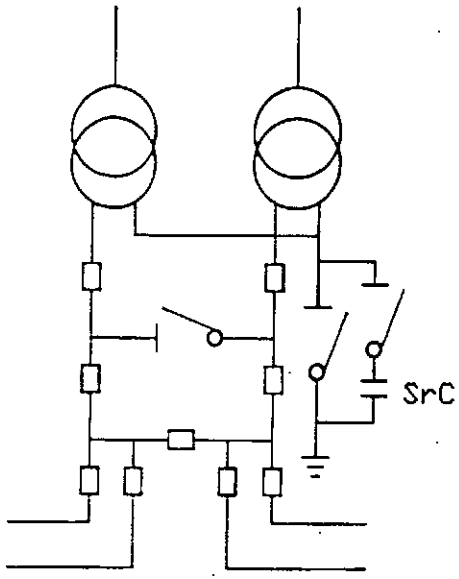
DT.	NAME
DR	
TC	
CK	

ETI/PSI/702-1

SCALE - N.T.S

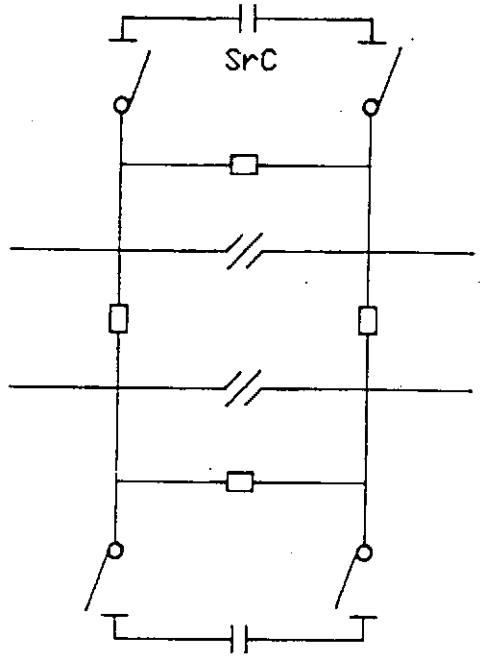
IR

CONNECTION DIAGRAM OF TSS



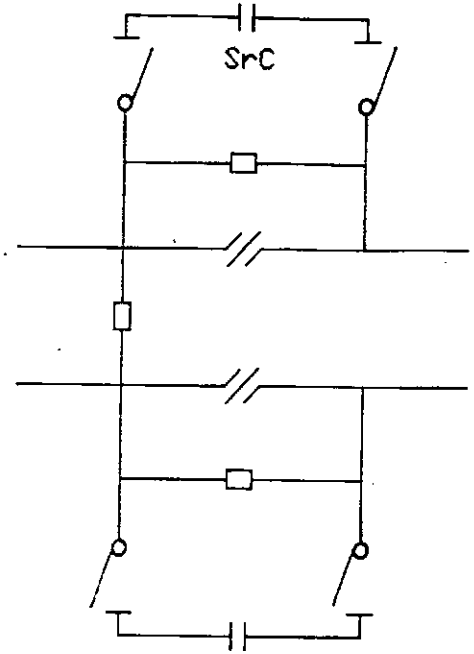
STYLE - 01

CONNECTION DIAGRAM OF SP



STYLE - 02

CONNECTION DIAGRAM OF SSP

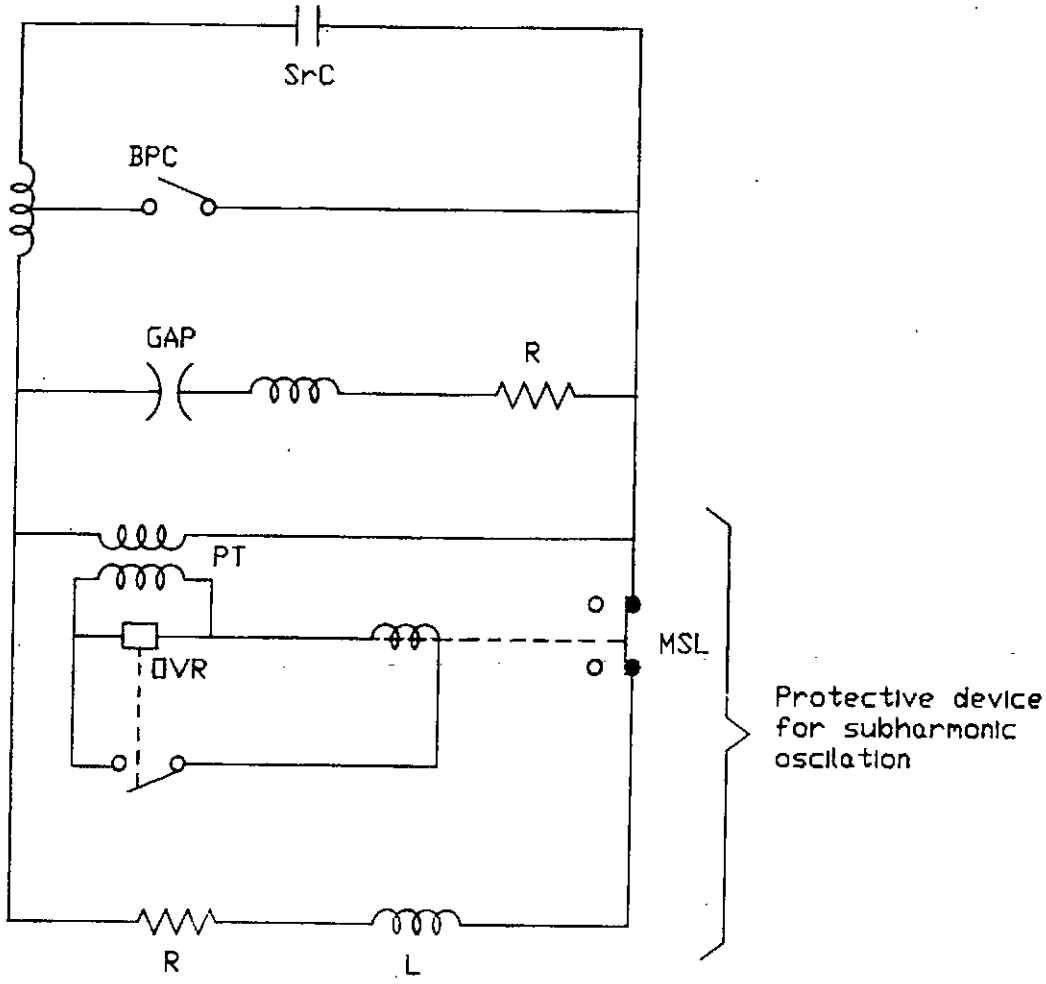


STYLE - 03

NOTE :-

Schemes are tentative, tenderer can subrit his own scheme also with detailed justification, acceptance of any new scheme shall be done by DG/TI/RDSO.

TYPICAL CONNECTION DIAGRAM OF SERIES COMPENSATION EQUIPMENT AT TSS, SSP AND SP



LEGEND :-

SrC	:	Series capacitor
GAP	:	Protective gap
BPC	:	Automatic bypass contactor
L	:	Saturable reactor
R	:	Damping resister
VR	:	Over voltage relay
MSL	:	Magnetic contact

TYPICAL CONNECTION DIAGRAM OF SERIES COMPENSATION EQUIPMENT AT TSS, SSP AND SP