Addendum & Corrigendum Slip No-02

to the RDSO's Specification No. TI/SPC/PSI/PROTCT/1982 for Delta I type high resistive fault selective Relay for 25 kV AC single phase 50 Hz Traction system.

New Clause No-15.0 added

"All the provisions contained in RDSO's ISO procedures laid down in document No.- QO-D-7.1-11 dated 19.07.2016 (Titled " Vendor- change in approved status") and subsequent versions/amendments thereof, shall be binding and applicable on the successful vendor/vendors in the contracts floated by Railways to maintain quality of products supplied to Railways".

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Lucknow-226011
Dated: 24.10.2016

A&C slip No.1–Oct,2013: to Technical specification No. TI/SPC/PSI/ PROTCT/1982 for Delta-I type high resistive fault selective relay for 25 kV AC single phase 50Hz traction system.

Amendment Number:	1
Reason of revision:	(i) Modification in Delta-I current detection principle. (ii)Addition of polygonal characteristic with load blinding. (iii)Up gradation of relay design features to bring at par with the current family of numerical protection.
Date of issue:	21.10.2013

Correct the specification No. TI/SPC/PSI/PROTCT/1982 with following corrections.

Sr. No.	Page & Clause	Existing	As amended
1.	Page 3 & 4 Clause 2.0	2.0 Principle of operation	Clause No. 2.0 to 2.6 deleted.
2.	Page 8 & 9 Clause 6.0 & 7.0	Design Feature	Clause No. 6.1 to 6.8 & 7.0 deleted and the following added: 6.1 CONSTRUCTIONAL FEATURES 6.1.1 The relays shall be of the draw-out (Plug-in), switch board type, back-connected and suitable for semi-flush or flush mounting, with dust-tight covers in dull black enamel finish. The enclosure class of module/relays shall be IP 54 as per IEC 60529. The measuring technique adopted should be based on digital numeric processing techniques. The analogue input received from CT and PT shall be transformed into a digital signal by using suitable A/D converter. The digital signal so obtained may be processed (with suitable signal analysis) to extract the various harmonic contents. 6.1.2 The numerical relays shall have in-built contact multiplication relays for alarm and trip conditions of CB. It shall be ensured that atleast two (02) numbers of auxiliary contacts for indication/annunciation and telesignalling functions are available. 6.1.3 The current coils/input module of relay shall be rated for 5 amps and capable of withstanding $3I_n$ continuously and short time rating shall be $40I_n$ for 1 sec. where I_n is rated current. The voltage coil shall be rated for 110V AC and capable to withstand 1.15 times of rated voltage continuously and 1.5 times for 3 seconds.

			6.1.4 The relays shall conform to the test voltage Class -III as per IS: 8686–1977/IS 3231 or latest and product safety requirements as per IEC:60255-27. 6.1.5 The relays shall be designed for continuous service (auxiliary supply) voltage of 110 V DC and shall be capable of satisfactory operation for +15 % and - 30 % fluctuation in voltage. 6.1.6 The relays shall have name plates with rating data, serial number and manufacturer's name marked on them. The metal case shall be provided with separate earthing terminals. 6.1.7 The relays shall be immune to distorted power frequency waveforms caused by the harmonics, phase shifts and transient faults and work on the principle of fundamental waveform extraction. The relays shall be immune to electro-magnetic interference and comply with IEC tests as mentioned in clause 9.2.1 (xiv). The relay manufacturer shall study the effect of harmonics present in the existing Railway traction supply system and its effect on the relay pick up values & operating time of the relay and suitable methodology shall be adopted to eliminate the effect of harmonics. 6.1.8 The relays shall be insensitive to power swings, permissible overloads and transient condition including magnetizing inrush current of locomotive transformers and shall be suitably designed to compensate the effect of fault arc resistance. 6.1.9 The numerical protection relays should have facility to record actual waveform of current and voltage alongwith all digital and logical status during fault condition. At a time up to 100 such waveforms for currents & voltage shall be storable and shall be retrievable through RS 232 serial communication port /or any other superior type of standard communication port through a Laptop computer. The duration of each disturbance record for current and voltage shall be at least 50 cycles (45 prior to and 5 after trip executed by relay). The disturbance record shall be triggered from physical status input as well as from pickup, trip operation of relay. 6.1.10 Suitable software shall be supplied along with the numerical relays to download and interpret the fault waveform and other data stored in the relays. The software shall be capable of analyzing the peak, RMS and average values of currents and voltage, dc component of currents, harmonic analysis of fault current waveforms. The accuracy of measurements shall be 1ms for time, 0.1 KV for voltages and 0.1 KA for currents. The software shall also be capable of

			communicating with the relay and viewing and modifying the settings. 6.1.11 The numerical relay manufacturers shall provide full support for up gradation of the software time to time to maintain the satisfactory performance throughout the useful life of the relay. The software should run on one of the current operating systems. 6.1.12 The numerical relays shall provide date and time stamping up to 1ms level for each fault. Relay shall have facility for clock synchronization through SCADA or any other similar synchronization facility like GPS etc. if available in future. 6.1.13 The numerical relays shall be capable of storing minimum 5000 events serially with date and time stamp of 1ms accuracy. The events definitions shall be configurable and generally include tripping of different protection elements, relay pickup, relay reset, relay blockrd due to harmonics or any other restraints, CB trip, CB close, changed of status input, relay setting changed, trip circuit monitoring etc. The events shall be retrievable through an external laptop/PC. 6.1.14 Operation counters shall be provided for each protection function with resetting facility. 6.1.15 The numerical relays shall have compact farm and every effort shall be made to minimize the hardwiring within the relays and maximum components shall be on the PCBs. The SMT (surface mounted technology) PCBs shall only be used. Suitable conformal coating to be provided on the PCBs. 6.1.16 The design shall be fail-safe and while designing the numerical relays, adequate redundancy shall be provided in various functional elements. 6.1.17 The numerical protection relays shall have self-diagnostic features. Suitable displays for confirming the module healthiness or defects shall be available. 6.1.18 Numerical relays shall have high contrast backlit LCD display of size at least 16 x 2 LCD characters for display of relay status, settings, on line parameter (current, voltage, resistance & reactance) etc. Bright LEDs shall be used for display of power ON conditions and trip/alarm indications of the each relay element. The parameters of the module shall be settable through a membrane keypad. 6.1.19 Provision shall be available to reset the indicating LEDs of protection module from relay and from RCC through SCADA. For this purpose suitable switch and NO/NC contact shall be provided in the module.

			6.1.20 The size of the module shall be suitable for flush mounting design for fitting on existing/new control and relay panels. The actual size shall be decided at the time of design approval. 6.1.21 The relay settings and stored data shall not get corrupted/erased/changed in the event of auxiliary / control supply voltage i.e. 110 V DC failure. 6.1.22 SCADA system is available for Railway traction application. For its full utilization in controlling/ monitoring of protection system, numerical relays shall be capable of communicating with the RTU or other IED's based on standard IEC 60870-5-103 protocol for transfer of information stored in relays to the RTU. The relay shall have necessary hardware and firmware interface for this purpose. 6.1.23 Suitable password protection shall be provided on the relays to avoid unauthorized changes in the relay settings. 6.1.24The making & breaking capacity and rated current of output contacts of the relays shall be adequate to operate the associated output relays/circuit breaker. Suitable snubber to be provided across the coil. 6.1.25 The module shall also be capable to display I (fault current), V(voltage), R(resistance), X(reactance), Phase angle, Delta-I current, fault clearing time and fault date & time (wherever applicable) of latest 100 faults at relay LCD, if it is not possible to display these parameters simultaneously on LCD display, then these parameters may accommodate in two window and displaying by pressing scroll Key . The CT's & PTs provided at TSS may have different ratios, hence to display the actual value (line value) of I, V, R, X ect. the CT primary current shall be settable in the range of 100 to 3000A in the steps of 50A and PT primary voltage shall be settable in the range of 20000V to 30000V in steps of 500V. On line current, voltage, Reactance & Resistance shall also be displayed on relay LCD. 6.1.26 The complete protection function shall be incorporated in single module. Trip, annunciation & telesignaling contacts for all the elements viz threshold detection (ΔI) & Polygonal characteristic etc. shall be individually available on the relay for external connection. 6.1.27 Suitable NO contact of each protection function shall also be available on the relay to start/stop auto reclosure function through status input, the auto reclosure function already provided in other protection module. 6.1.28 The relay shall be suitable for operation from the 25 kV current transformers and potential transformer of the following particulars:

Current Transformer

1.	Rated system voltage (phase to ground)	Normal: 25 kV Maximum: 30 kV Minimum: 19 kV
2.	Rated transformation ratio	1000-500/5 A or 1500-750/5 A or 3000-1500/5A
3.	Rated burden	60 VA
4.	Rated accuracy limit factor	15
5.	Class of accuracy	5P class as per IS:2705 (Pt.III) 1981

Potential Transformer

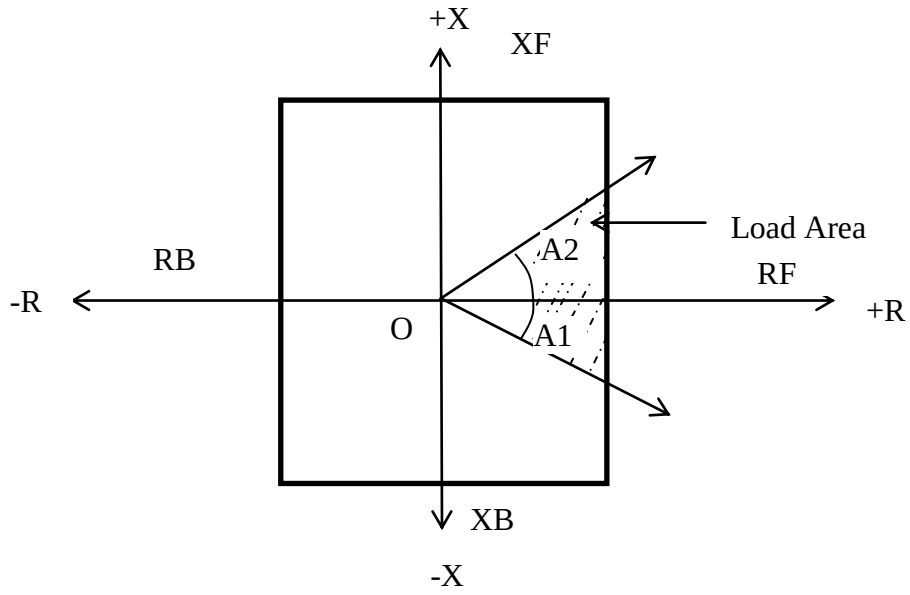
1.	Rated system voltage	Normal: 25 kV Maximum: 30 kV Minimum: 19 kV
2.	Rated transformation ratio	25000/110V
3.	Rated burden	100VA
4.	Rated accuracy limit factor	-
5.	Accuracy class	1.0 as per IS:3156 (partII) & 3P as per IS:3156 (partIII)-1992

6.1.29 The relays shall generally conform to following standards.

1.	Dielectric Withstand	2kv, 50 Hz for 1 min between circuit to earth/circuit to circuit (IEC 60255-5, IS: 3231, IS: 12083 Pt.II)
2.	Impulse voltage test	5 kV, 1.2/50 micro seconds (IS: 8686/ IS: 3231/IEC-60255-5, IS: 12083 Pt.II)
	High frequency disturbance	IEC 60255-5, IS: 3231 part-I section-III Longitudinal mode 2.5kV, 1 Mhz across auxiliary dc and current/voltage sensing terminals an earth. Transverse mode 1 kV, 1 Mhz across auxiliary dc and current/voltage sensing terminals.
3.	Contact data	IS: 3231 part-I , IS : 12083 part-I
a.	Current carrying	5 Amps Continuously at 110 V DC/ 230 V AC

				capacity	
			b.	Making & carry 250 V ac, 50 Hz for 3 seconds:	30 Amps
			c.	Breaking: 220V, 50-60 Hz -Cos Ø 0.4 220 V dc, L/R = 45 mili sec	5A 0.5 A
			4.	Auxilary power consumption at 110V DC	<15 W – De energised <30 W – Energised
			6.2 Protection function, working Principle and settable parameters The relay shall have following characteristics (i) Threshold Detection of Vectorial difference of current from suitable base Characteristic (ΔI) (ii) Polygonal characteristic with load blinding 6.2.1 Threshold Detection of Vectorial difference of current from suitable base Characteristic (ΔI) 6.2.1.1 The relay monitors vectorial difference between base load current and fault current. The vectorial difference shall be calculated in such a manner to ensure detection of high resistance faults even if fault is not detected in current samples the same shall be detected in next sample. The time difference between base load current sample and fault current sample to calculate vectorial difference shall be settable in the range of 20ms to 200ms in steps of 5ms. The Vectorial Delta-I current shall be settable in the range of 0.1A to 6A in the steps of 0.1 Amp.Vendor to give details of detection process and how the design assures reselinece and improves probability of detection of a fault. 6.2.1.2 To calculate vectorial current difference, relay calculates current vector and save it in to a circular buffer after every 5ms, the length of memory buffer should be at least 200ms. The relay calculates scalar and vectorial difference between instantaneous vector and earlier vector (as per time set on the relay). If scalar difference is positive and vectorial difference is more than set Delta-I current then relay start tripping timer. When tripping timer start, relay should stop base vector updating. During set operating time delay if vectorial difference remains more than set Delta-I current relay execute trip command.			

			6.2.1.3 The relay should provide a prevention circuit for unnecessary operation by the inrush current of power transformer and due to starting of multiple numbers of electric locomotives in the section. The inrush currents of power transformers contain significantly high 2^{nd} harmonics currents. If the 2^{nd} order harmonic component is more than set value, the relay should block tripping, thus preventing unnecessary operation of the relay. The value of second harmonic percentage to block relay trip command shall be settable from 5% to 20% in steps of 1% of the fundamental components. 6.2.1.4 The relay should operate by Vectorial delta-I current threshold set if 3^{rd} harmonic components are less than set value. The relay sensitivity should restrain according to the de-sensitivity setting when Vectorial delta I current include 3^{rd} harmonic components more than set limit. The value of 3^{rd} harmonic percentage to restrain according to de-sensitivity setting shall be settable from 5% to 30% in steps of 1% of the fundamental components. If 3^{rd} harmonic component in the current more than set 3^{rd} harmonic percentage then relay operating value shall be automatically increased as given below. Operating value of vectorial Delta-I current = [(Set Vectorial Delta-I current * % De-sensitivity setting)/(100) + (Set Vectorial Delta-I current)] De-sensitivity setting shall be settable from 0% to 100% in steps of 10%. 6.2.1.5 The normal operating time of relays in no case shall be more than 80 ms Additional time delays from 0 to 800 ms settable in steps of 10 ms shall be provided to the relay. 6.2.1.6 The relay shall continuously sense the status of feeder protection relay through the MTR status and give trip command to the breaker only when these relays have failed to clear the fault. 6.2.1.7 The operating value error of the relay shall not be more than $\pm$ 5 %. 6.2.1.8 Delta-I relay shall have also a feature to detect the rate of change of impedance. If tripping needed based on the rate of change of impedance may be finalized during design drawing approval by RDSO and manufacturer. The rate of change of impedance and operating time shall be settable in suitable steps 6.2.2 Polygonal (on R-X plane) characteristic 6.2.2.1 Characteristic shall be polygonal on R-X plane characteristics having forward as well as reverse reach. The forward and backward Resistance (R) and Reactance (X) shall be settable individually. To avoid malfunction of relay due to load encroachment, the load impedance area of the polygonal shall be settable for non tripping in case impedance falls in this area. The following setting range of polygonal shall be available on the relay.



Setting	Range and steps
Forward Resistance (RF)	0.04 – 99.99 Ω in steps of 0.01 Ω
Backward Resistance (RB)	0.04 – 99.99 Ω in steps of 0.01 Ω
Forward Reactance (XF)	0.04 – 99.99 Ω in steps of 0.01 Ω
Backward Reactance (XB)	0.04 – 99.99 Ω in steps of 0.01 Ω
Angle (A1)	00 – 70 deg in steps of 1 deg
Angle (A2)	00 – 70 deg in steps of 1 deg
Zmin	00 – 99.99 Ω in steps of 0.01 Ω

6.2.2.2 The normal operating time of relay shall be 30 ± 10 ms. Additional time delay shall be settable in the range from 00 to 1000 ms in steps of 20 ms.

6.2.2.3 The relay shall be blocked for operation in case 2nd harmonic component in current exceeds more than set value. The percentage of second harmonic for block the operation shall be settable from 10 to 20 % in steps of 1%.

			6.2.2.4 Relay shall have local breaker backup protection (LBB) feature for threshold Detection of Vectorial difference Characteristic (ΔI) and Polygonal characteristic; the relay shall continuously monitor the status of closing of the feeder CB. In case the feeder CB is not tripped after a preset time interval settable in the range of 0 to 1000 ms, in steps of 10 ms after initiating the trip command then another trip command shall be executed to trip upstream breaker. 6.2.2.5 The operating value error of the relay shall not be more than ± 5 % including for voltage input to the relay from 125 volts down to 0.5 Volts and current 0.5A to 100A, the frequency variations of 47 to 52 Hz and the ambient temperature variation over the range –20 ^{O}C to + 50 ^{O}C. 6.2.2.6 The relay shall have settable minimum operating current. If current less than set value of minimum operating current then relay should not execute trip command even though impedance measured by relay fall inside set polygonal on R-X plane characteristic. Minimum operating Current shall be settable in the range of 0 to 1Amp in the steps of 0.1 Amp. 6.2.2.7 The relay shall discriminate correctly between faults in the forward and reverse directions on the event of voltage input to the relay falling down to 0 V. The polarizing signal shall be derived from sufficient samples of the pre-fault voltage held in memory.
3.	Page 12,13,14 & 15 Clause 9.2 & 9.3	Type tests	Clause No. 9.2 & 9.3 deleted and the following added: 9.2 Type & Routine tests on protection relays 9.2.1 Type tests The protection relays covered by this specification shall be type tested as per IS:3231, IS: 12083 IS:8686, IEC 61000 & IEC: 60255. The following type tests shall be carried out on the prototype relays by RDSO. i) Operating characteristics tests including verification of all relay functions/features including operating time reset time, operating and reset value. ii) Insulation resistance test- should be 10 mega ohm or more between the electric circuit and earth with 1000 V. iii) Measurement of burden (VA). iv) Measurement of power consumption (watts). v) Over load test. vi) Impulse voltage withstand test applicable to test voltage class III. vii) Temperature rise test. viii) Effect of DC voltage variation (110 V DC +15 % / -30 %). ix) Making and breaking capacity tests of contacts.

			x) Dielectric test. xi) Vibration test- as per IEC 60255-21-1, Clause-I- Frequency 10-150 Hz, acceleration $1g_n$ in all 3 axis, 20 sweep @ 1 octave/minute. xii) Endurance test-Mechanical endurance test for 1000 operations. xiii) Environmental test a) (i)Dry heat test as per IEC 60255-1/IEC60068-2-2 (This will test from +20 to +70 ^{0}C) (ii) Cold test as per IEC60255-1/IEC60068-2-1 (This will test from -25 to +25 ^{O}C) (iii) Change in temperature as per IEC60255-1/IEC60068-2-14 Nb (this will test from -25 to +55 ^{O}C) b) Damp heat test, steady state as per IEC 60068-2-78 c) Damp heat test, cyclic as per IEC 60068-2-30 xiv) EM Compatibility tests a) 1 MHz burst immunity test as per IEC60255-26 & IEC61000-4-18 :Common Mode : 2.5kV Differential mode : 1kV Duration : 2 sec b) Electrostatic Discharge Test as per IEC60255-26 & IEC61000-4-2 Contact Discharge 6kV, Air Discharge 8kV c) Radiated, radio-frequency, electromagnetic field immunity test as per IEC60255-26 & IEC61000-4-3Frequency Range: 80MHz – 1000MHz, Modulation: 80% AM @1kHz, Field Strength 10V/m d) Electrical fast Transient or burst requirements as per IEC60255-26& IEC61000-4-4. e) Surge immunity as per IEC60255-26 & IEC61000-4-5. f) Immunity to Conducted disturbances induces by radio frequency field as per IEC60255-26& IEC61000-4-6. g) Power Frequency Immunity Test as per IEC60255-26& IEC61000-4-16. h) A.C. ripples in D.C. auxiliary as per IEC60255-26 & IEC61000-4-17. 9.2.2 Type tests for which facilities of testing are not available with the relay manufacturer shall be carried out at any reputed & NABL accredited govt/ semi govt. approved laboratories and test reports of the same shall be furnished to the RDSO. 9.2.3 Only after approval of the results of the tests on the prototype is communicated by RDSO/Purchaser to the manufacturer, shall he take up bulk manufacture and future supplies of the relays which shall be strictly with the same material and process as adopted for the prototype. In no circumstances material other than those approved in the design/drawings and/or the prototype shall be

			used for bulk manufacture. 9.2.4 <u>Routine tests</u> The following tests on the protection relays shall be carried out during routine tests by Railways/ inspecting agencies at the manufacturer's works as per this specification. (i) Visual Checks (ii) Insulation Resistance (iii) Dielectric strength (iv) Setting range and Functional tests
4.	Page 16 Clause 14	Warranty	Clause No. 14 deleted
5.	Page 10, 11 & 12 Clause 8.0	Electrical performance	Clause No. 8.0 (clause 8.1 to 8.11) deleted

GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

TECHNICAL SPECIFICATION

DELTA I TYPE HIGH RESISTIVE FAULT SELECTIVE RELAY FOR 25 KV AC SINGLE PHASE 50 HZ TRACTION SYSTEM

SPECIFICATION NO: TI/SPC/PSI/PROTCT/1982

ISSUED BY

RESEARCH DESIGNS & STANDARDS ORGANISATION, MANAK NAGAR,
LUCKNOW-226011

SPECIFICATION FOR Delta I type high resistive fault selective relay for 25 kV AC single phase 50 Hz, traction system.

SPECIFICATION NUMBER: TI/SPC//PSI/PROTCT/1982

Amendment Number	Amendment /Revision	Total pages including drawings	Date of Issue
0	Draft	26	17th May 1998
1	Prototype	26	19th June 1998
2	SPECIFICATION FOR BETTER RELIABILITY	23	9 th December 2003

	PREPARED BY	CHECKED BY	APPROVED BY
SIGNATURES			
DATE			
DESIGNATION	ADE/TI-III	DTI/ III	EDTI

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INDEX

ANNEXURES

1. 0 NEED FOR THE RELAY.

1.1 Electrified railways reported in the XIX th and XX th MSG Trd meeting the need for a back up protection for the existing mho relays. Cases of low current faults have led to the failure of the mho type distance relays on various Zonal Railways. Normally a distance protection relay is used to protect the faults occurring in OHE on 25 kV AC traction system; however, it is difficult to detect the earth faults having a high resistance, or the far end faults with the present mho type distance protection. In case of such faults, the fault is cleared by the transformer OCR (IDMT) and that too after a considerably longer time period which may be dangerous for the OHE and may cause OHE damage or even parting.

1.2 Far end fault current may be of lesser magnitude as compared to the starting load current and shall remain undetected by the mho type of distance protection relay. It was observed that in such cases the fault remained beyond the reach of mho protection relay. Clearing of such faults can be possible by increasing the sensitivity of the existing mho relay and the over-current relays but than the phenomena of unnecessary tripping of the CB's due to load encroachment (starting of a number of locomotive together) shall occur.

1.3 A closer look at the wave form of the starting currents and the fault currents gives a clue for distinguishing the two. The absolute value of the increasing current (Delta I current) in case of faults differ from the normal operation delta I currents of the AC locos/EMU's . On comparison of the delta I current of the fault current and the load current, it has been observed that the former is mostly a sine wave current and the later is strain current wave which includes substantial, 2^{nd} , 3^{rd} & higher order harmonics.

1.4 RDSO had developed scalar Delta I relay to earlier specification No. TI/SPC/PSI//1981.This relay was detecting scalar delta I current for its operation. In this case the fault current was the sum of base load current and scalar delta I current .With the advancement of protection technology for high impedance earth faults, more accurate and reliable relay for such an application is developed . In this type of relay vectorial delta I current is detected which is the Vectorial difference of base load current and the fault current.

1.5 At present there is no back up protection for the distance relay which is used for providing protection for distance faults having currents lower than the load currents. Keeping all these aspects in view, it was decided in XIX th & XX th MSG TrD meetings that RDSO should develop Delta I relay as backup to distance protection in 25 kv AC conventional system.

2.0 PRINCIPLE OF OPERATION:

2.1 The AC delta I relay should easily detect the Vectorial difference between the base load current and fault current. The relay should provide a prevention circuit for unnecessary operation by the inrush current of power transformer and due to starting of multiple number of electric locos in the section. The inrush currents of power transformers contain significantly high 2^{nd} harmonics currents. If the 2^{nd} order harmonic component is larger than 15% of the fundamental components, the relay should block out, thus preventing unnecessary operation of the relay.

2.2 The relay under fundamental frequency, should operate by Vectorial delta I current at the same value as of setting current notwithstanding the magnitude of base current. The relay sensitivity however should restrain according to the de-sensitivity setting at set current when Vectorial delta I current include more than 15% of 3^{rd} harmonic current.

2.3 Relay should continuously monitor the reactance (X) of OHE at the fault point and ensure the operation when X value so measured falls below the set value and vectorial delta I current is more than set current.

2.4 The relay shall act as a back up to the main directional distance protection. The relays operating time in no case shall be more than 80 ms Additional time delays of 250 ms settable in steps of 25ms shall be provided to the relay.

2.5 The relay shall continuously sense the status of feeder protection relay through the MTR status and give trip command to the breaker only when these relays have failed to clear the fault

2.6 The measuring technique adopted should be based on digital numeric processing techniques. The analogue input received from CT and PT shall be transformed into a digital signal by using suitable A/D converter. The digital signal so obtained may be processed (fourier analysis) to segregate the various harmonic contents. The numeric processors are used to carry out the various calculation as brought out in item 2.1 to 2.5 so as to give the final trip signal.

3.0 SCOPE

3.1 This specification applies to design, manufacture and supply of Delta I type fault selective relay for the protection of OHE of 25 kV ac traction system.

3.2 The relay shall be complete with all parts and accessories including auxiliary relays necessary for their efficient operation. All such parts and accessories shall deemed to be within the scope of this specification whether specifically mentioned or not.

3.3 This specification supersedes specification No. TI/SPC/PSI/PROTCT/1981.

4.0 TRACTION POWER SUPPLY SYSTEM

4.1 General scheme of traction power supply system.

4.1.1 Power is received from the grid network of the state electricity board at 220kV/132kV/110kV/66 kV at individual traction substation (TSS). 25kV power supply for traction is drawn through a single phase step down traction transformer. The primary winding of this transformer is connected to any two nominated phases of the incoming three phase lines or to the two incoming phase lines and on the secondary side, either of the two terminals of the 25 kV winding is connected to the traction overhead equipment, while the other is solidly earthed and connected to the running traction rails.

4.1.2 Each transformer has its associated circuit breakers on the primary and secondary sides, with a separate set of 25 kV circuit breakers called " feeder Circuit Breakers" for feeding the traction OHE lines.

4.1.3 Adjacent TSS are fed from different phases of the three phase system in rotation. Neutral sections in front of sectioning and paralleling post (SP) are provided in the 25 kV OHE for segregating the different phases. In between the TSS and SP, sub-sectioning and paralleling posts (SSP) are provided for paralleling the UP and DN line OHE and also for sectionalizing and fault localization. The attached drawing at Annexure-5 shows the general scheme for traction power supply system.

4.1.4 The supply to the OHE can be switched ON/OFF through interruptors which do not open automatically on fault but can be closed on to a fault. The fault is cleared by the feeder circuit breaker provided at the traction substation.

4.1.5 Normally power supply from a TSS extends upto the SP on either side of the substation, but in case of an emergency necessitating total shut down of the substation, power supply from adjacent TSS on either side of the failed substation can be extended upto the failed substation by closing the bridging interruptors at the two SPs.

4.2 Nature of traction load and faults on the system.

4.2.1 The traction load is a frequently and rapidly varying one between no load and overload. The TSS equipment is subject to a number of earth faults/short circuits. On an average the number of faults/short circuits per month is about 40 but in exceptional cases the number could be as high as 120. The magnitude of fault current may vary between 40% and 100% of the dead short- circuit value.

4.2.2 The ac electric rolling stock is fitted, for conversion of ac to dc, with single phase bridge-connected silicon rectifiers with smoothing reactor for feeding the dc traction motors. The rectifiers introduce harmonic currents in the 25 kV Power supply. On few locomotives there are controlled asymmetrical thyristor bridge and GTO Pulse width modulation devices, in place of silicon rectifiers. A typical percentages of harmonics present in the traction current with electric rolling stock are as follows:

TABLE -1: Harmonic Generated by IR Locomotives

S.No	**Harmonic No.**	**With Diode Rectifier**	**With Thyristor**	**With GTO's**
1.	3rd harmonic(150 Hz)	15%	23%	3%
2.	5th harmonic(250 Hz)	6%	14%	2%
3.	7th harmonic (350 Hz)	4%	10%	0.5%
4.	9th harmonic(450 Hz)	-	4%	0.35%
5.	11th harmonic (550 Hz)	-	3%	0.4%
6.	THD's	16.64%	29.15%	3.68%

Indian Railways have introduced a superior breed of locomotives which has a much better harmonic profile as shown in table 1. Also the quantum of thyristor based locomotive too small to effect a major increase in the harmonics. It is expected that the harmonic profile shall gradual reduce from the existing values as shown in table 2. The relay shall be so designed that it is flexible enough to cater for the future harmonic profile of India Railways also particularly when the harmonic levels of the traction system drops to 50 % of the existing system values.

The relay should have proper adjustment to cater for the present and the future harmonic profile which differ in various areas and is shown as below in table 2

TABLE 2: Actual percentage of individual harmonics present in the traction current as measured during 1990-1992 at various zonal railways

Zone	Eastern		Northern		Central		Southern		Western		All India
Harmonic	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	**A**	**B**	Average
3rd	18	18	19	17	19	17	19	19	18	18	20
5th	8	8	9	7	9	8	9	9	9	9	10
7th	4	4	5	4	6	5	8	7	5	5	8
9th	3	2	3	3	4	3	4	3	4	4	4
11th	2	2	3	3	-	-	2	2	3	2	3

A - Load current range 200-300 Amps.

B - Load current range 300-400 Amps.

4.2.3 The average power factor of the electric locomotive and electric multiple units generally varies between 0.7 and 0.8 lagging, without compensation.

4.3 Short circuit apparent power of the system

4.3.1 The short- circuit apparent power for various system voltages is as under:-

Table No. 3: Short Circuit Level

Highest system voltage Kv	**Short circuit apparent power MVA**
52	200
72.5	3500
123	6000
145	10000
245	20000

4.4 Power supplies at traction substation

4.4.1 The following power supplies are available at a traction substation.

i.) 110 V +15/- 30% dc from a battery.

ii) 240Vac,50Hz,single phase from a 25/0.24 kV auxiliary transformer.

4.5 Booster Transformers

4.5.1 In order to reduce inductive interference in adjacent telecommunication circuits booster transformers on certain sections of electrified track are installed in series with the 25 kV traction overhead equipment. The primary winding of the booster transformer is connected to the 25 kV overhead equipment and the secondary winding is in series with the return conductor (RC) which is strung close to the 25 kV overhead equipment. Booster transformer with a rating of 150 or 100 kVA provide necessary voltage to force the traction return current from the rail and earth to flow through the return conductor. The Booster transformers have a leakage impedance of about 0.15 Ohm each and are spaced about 2.66 km apart.

4.6 Protective relays at the traction sub-stations

4.6.1 For protection of transformer, substation equipment's, shunt capacitor bank feeders, the following relays are provided on control panels housed in the masonry cubicle at the traction substation (TSS).

4.6.1.1 Transformer Protection

i.) Differential relay

ii) IDMT over-current relays for the primary (HV) as well as for the secondary (LV) side. The IDMT relay on the HV side is also provided with an instantaneous over-current element.

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

iv) High speed inter-tripping relay.

v) Auxiliary relays for transformer faults i.e. Bucholz, excessive winding and oil temperature trip and alarm and low oil level alarm.

4.6.1.2 Over head equipment protection.

i.) Admittance/parallelogram type directional distance protection relay.

ii) Admittance type relay for protection against wrong phase coupling.

iii) Instantaneous over-current relay.

iv) Delta –I type fault selective relay.

v) Panto flash over protection relay.

4.6.1.3 Shunt Capacitor Bank Protection.

i.) IDMT over-current protection relay with suitable settings.

ii) Over voltage protection relay.

iii) Under voltage protection relay with timer to enable the capacitors to discharge before re-closure.

iv) Current unbalance protection.

v) Internal fuse for each capacitor element.

4.7 Auto-re-closing of feeder circuit breakers.

4.7.1 A single shot high speed auto-re-closing scheme for 25 kV feeder circuit breaker(s) at AC traction sub-station has been adopted to facilitate re-closing of the 25 kV feeder breaker automatically once after a pre-set time delay after tripping of the circuit breaker on OHE fault. This feature will help in quick restoration of traction power supply to OHE if the fault is of a transient nature. It will also help in checking/restricting the continuance of arc in the event of the pantograph of a moving locomotive passing the overlap opposite feeding post at such moments and thus protecting the OHE, catenary in particular, from consequent damages.

4.8 Inter tripping of feeder circuit breakers.

4.8.1 In the event of failure of a traction substation 25 kV supply is extended from the adjacent substations by closing the bridging interruptors at SPs. Under such emergency feed conditions, wrong phase coupling may be caused at the overlap opposite the failed substation by the pantograph of a passing locomotive, resulting in the tripping of 25 kV feeder breaker at any one of the two substations through wrong phase coupling (Mho) relay. This may result in the formation of an arc at the overlap due to which the OHE may be damaged. The damage due to the arc can be minimized by tripping the feeder circuit breaker at the other substation also. This is achieved by an inter-tripping arrangement through the remote control equipment.

4.8.2 For the purpose of calculation, the values of loop impedance with earth return for the OHE are taken as under:

TABLE 4 OHE Line Impedance

1.	One OHE without BT and RC	0.41 ∠70 ° Ohms/km
2.	Two OHEs without BT and RC	0.24 ∠70 ° Ohms/km
3.	One OHE with BT and RC	0.70 ∠70 ° Ohms/km
4.	Two OHEs with BT and RC	0.43 ∠ 70 ° Ohms/km

4.9 Traction Power Transformer

The percentage impedance of a 21.6 MVA, 220 or 132 or 110 or 66/27 kV single phase transformer is 12%. The traction transformers are designed to carry short time overloads as the traction loads may exceed 21.6 MVA for short periods. The impedance angle for the loads at the traction substation is nearly 37^{0}.

4.10 Nature of faults on the over head equipment (OHE) system.

4.10.1 OHE is subjected to frequent earth faults caused by failure of insulation, or by the OHE snapping and touching the rail or earth, or by a piece of wire dropped by birds connecting the OHE to earthed overlying structures, miscreant activities etc. These faults are cleared by the feeder circuit-breaker which operates on any one or more of the following relays :

i) Distance protection relay.

ii) Instantaneous over-current relay.

5.0. SERVICE CONDITIONS

5.1 The relays are intended for use in moist tropical climate with the following atmospheric conditions :

TABLE 5 Service Conditions

1.	Max. temperature of air	50 ° C
2.	Min. temperature of air	0°C
3.	Max. temperature attainable by an Object exposed to Sun	65° C
4.	Max. relative humidity	100%
5.	Max. wind pressure	200 kgf/sq.m.
6.	Altitude	> 1000 m
7.	Average annual rain fall.	1750 to 6250 mm.
8.	Number of thunderstorm days per annum.	85 days.
9.	No. of rainy days per annum	120 days (Max.)
10.	Average No. of dust storm days	35 days per annum.
11.	Vibrations	Max: 350 micron Average : 30 – 150 micron time duration : rapidly varying time duration 15 - 70 ms.

5.2 The relays shall be installed in the control and relay panel at the traction substations which are normally unattended. The panels are situated close to the Railway tracks and hence the Panels are subjected to vibrations due to running trains.

6.0 DESIGN FEATURES

6.1 The normal zone of feed from a substation to SP varies between 20 and 30 km. Under emergency feed conditions, however, the zone would extend upto the next substations or double the zone of normal feed. It will be apparent from the impedance values given above, that the fault current under such conditions can be well below the traction load current. Moreover, in case of a high resistance earth fault, the fault current can be also below the traction load current. Therefore, relay working on the principle of discrimination of a Vectorial Delta I current is required.

6.2 The relay shall be designed to cover the entire range from the substation to the adjacent substation with single track OHE, as a worst case. The relay shall be insensitive to power swings, heavy overloads and transient condition including magnetizing inrush currents of locomotive transformers and shall have strong immunity to variations in arc resistance of fault.

6.3 The relay should operate by Vectorial delta I current at the same value as of setting current notwithstanding the magnitude of base current. The relay sensitivity should restrain according to the de-sensitivity setting at the set current when Vectorial delta I current include 15% or more of 3^{rd} harmonic current.

6.4 Relay should be restrained from operation if 2^{nd} harmonic contents is 15% or more to avoid mall-tripping due to inrush currents during the switching of the locos, transformers.

6.5 Relay should continuously monitor the reactance (X) of OHE and ensure the operation when X value so measured at the instant to fault falls below the set value and vectorial delta I current exceeds the set vectorial delta I current.

6.6 The relay shall act as a back up to the main directional distance protection. The relays operating time in no case shall be more than 80 ms Additional time delays of 250 ms settable in steps of 25ms shall be provided to the relay.

6.7 The relay shall continuously sense the status of feeder protection relay through the MTR status and give trip command to the breaker only when these relays have failed to clear the fault

6.8 The proposed scheme of connection of Vectorial delta I type fault selective relay in the existing protection scheme is indicated at Annexure-6. The relay shall be suitable for operation from the 25 kV current transformers and potential transformer of the following particulars:

TABLE 6 CT Ratio

1.	Rated system voltage (phase to ground)	25 kV raising upto 30 kv and going down to 19 kV
2.	Rated transformation ratio	1000-500/5 A or 1500-750/5 A
3.	Rated burden	60 VA
4.	Rated accuracy limit factor	15
5.	Class of accuracy	5 P class as per IS:2705 (Pt.III) 1981

TABLE 7 PT Ratio

S. No	Description	PT
6.	Rated system voltage	25 kV rising upto 30 kV
7.	Rated transformation ratio	25000/110V
8.	Rated burden	100VA
9.	Rated accuracy limit factor	-
10.	Accuracy class	1.0 as per IS:3156 (partII) & 3P as per IS:3156 (partIII)-1992

7.0 RATING AND OTHER PARAMETERS.

TABLE 8 Technical Particulars of the relay

1.	Rated CT secondary current, In	5A
2.	Ratings: Delta -I current setting	By means of functional keys on front panel 1.0 A to 6 A in steps of 0.1 Amps
3.	Range of reactance setting (Blinder)	0.50 to 30 ohm in step of 0.01 ohm.
4.	De-sensitivity setting in case of 3rd harmonic detection	0% to 100% in step of 10%
5.	Relay operating current	Current setting Value $\pm$ 7.5%
5.1	Pure sine wave, 50 Hz only	
5.2	Complex wave with 50Hz and 150 Hz components.	50 Hz component**:** 200% of set value +- 7.5 % of the fundamental current.
6.	Second harmonic blocking	When 100 Hz component > 15% $\pm$ 1.5% of the fundamental current
7.	Operating time	Minimum of 70 ms
8.	Additional time delay (settable)	0.0 to 250 ms in step of 25 ms.
9.	Rated frequency	50 Hz $\pm$ 3%
10.	Control Voltage	110 V DC +15 % / - 30%

11.	Power consumption	15 W - de energized 30 W - energized
12.	Overload capacity (In = 5A)	10 In for 3 seconds 3 In continuously
13.	Operating temperature range	-5^0 C to + 55^0 C
14.	Insulation resistance by 1000V megger.	10 Mega-Ohms (minimum) between all electrical terminals (shorted) to earth
15.	Dielectric withstand voltage	2 kV rms, 50 Hz for one minute between circuit to earth / circuit to circuit
16.	Impulse voltage test	5 kV peak, 1.2/50 micro seconds
17.	High frequency disturbance test.	Longitudinal mode : 2.5kV, 1Mhz across auxiliary DC and current/voltage sensing terminals and earth.. Transverse mode : 1 kv , 1Mhz across aux. DC input/voltage/current terminals.
18	Current carrying capacity	5 A continuous at 110 V DC/230 V AC
18.1	Making & carry 250VAC,50-60Hz, for 3 sec.	30 A
18.2	Breaking:	
18.2.1	250 V 50-60 Hz, Cos ø = 0.4	5A
18.2.2	220 V DC, L/R = 45 m sec	0.5 A
19.	LCD Display	Relay designation Setting (in set mode)
20.	LED indication	Green - power on Red for Delta I trip

8. 0 ELECTRICAL PERFORMANCE

8.1 Operating characteristics:

8.1.1 Fundamental and Operation Current Characteristics

The relay shall actuate on Vectorial Delta I current. The Vectorial Delta I current is the Vectorial difference between base current and fault current. The relay shall continuously sense the status of feeder protection relay through the MTR status and give trip command to the breaker only when these relays have failed to clear the fault. Relay shall also monitor the X value and shall ensure the operation of relay only if measured X value falls below the set value of X. blinder.The permissible error should be within +/- 7.5% of the set value.

8.1.2 Vectorial Characteristics

The relay should consider phase angle difference between fault and base current and not scalar values for its operation, to discriminate between scaler Delta-I and vectorial Delta-I relay.

8.1.3 3rd Harmonic De-sensitivity

By Delta –I current which contains 15% or more third harmonic, the relay should be operated at 200 % of the set value. The permissible error should be within +_ 7.5%. however, the base current is less than 5A.

8.1.4 2nd Harmonic Operation blocking

The blocking (restraint) of the relay unit operation should be confirmed when the second harmonic (100 Hz) content is 15% (+/-1.5) or more of fundamental (50 Hz) wave current.

8.1.5 Reactance (X) blinder Range
0.5 to 30 ohm. In steps of 0.01 ohm

8.1.6 Operating Time
Operating time shall more than 70 +-5ms. The additional time delay shall be 0 to 250 ms in steps of 25 ms..

8.1.7Verification of operation of relay with X Blinder setting within operating time.

If X value remains less than set X blinder then relay shall give trip command after time delay. If X value becomes more than set X blinder during operating time, then relay shall block the trip command

8.2 Overload Capacity
10 times the rated current for 3 second.

8.3 Rated VA burden
0.5 VA, or less

8.4 Control voltage and power consumption
DC 110 +15/-30% V, 30 W or less

8.5 Making and Breaking Capacity of Contact Test

8.5.1 Make and Carry current of 30 A at 250 V a.c. for 3 Sec.
8.5.2 Breaking capacity: Breaking current of 5 A at 250 V a.c. (50Hz), Cos Ø 0.4 and 0.5 Amp at 220 V dc with load L/R = 45 milli Sec.

8.6 Temperature Rise Limit
When used continuously, passing the rated current, the temperature rise limits shall be follows:

Coil	: 40^{O} C
Internal Resistor	: 70^{O} C
External resistor	: 140^{O} C

8.7 Insulation Resistance
10 mega- ohms or more between the electric circuits and the external case.

8.8 High Frequency Disturbance Test
i) Longitudinal mode – 2.5 kV, 1 MHz across auxiliary DC and current / voltage sensing terminal of the relay under test and earth..
ii) Transverse Mode: - 1 kV, 1 MHz across DC input /voltage/current terminals.

8.9 Impulse Voltage Withstand Test
5 kV peak and waveform 1.2 / 50 micro-Second

8.10 Dielectric Strength
2 kV, 50Hz AC for 1 minute.

8.11 Vibration Proof

Frequency 16.7 Hz, maximum amplitude 0.4 mm, 10 minutes each for back and forth, for right and left, and for up and down.

9.0 TESTS

9.1 General

9.1.1 Only after all the design and drawings have been approved and clearance given by Research Design and Standards Organization (RDSO)/Chief Electrical Engineer(CEE) to this effect, the manufacturer shall take up manufacture of the prototype unit for RDSO inspection. It is to be clearly understood that any changes required to be done in the prototype unit shall be done expeditiously.

9.1.2 Before giving the call to RDSO/CEE for inspection and testing of the prototype of the equipment, the manufacturer shall submit a detailed test schedule consisting of schematic circuit diagrams for each of the tests and nature of the test, venue of the test and the duration of the test and the total number of the days required to complete the tests at one stretch.

9.1.3 Once schedule is approved, the tests shall be done accordingly. However, during the process of type testing or even later, RDSO representative reserves the right to conduct any additional test(s) besides those specified therein, on any equipment/sub-system or system so as to test the equipment to his satisfaction or for gaining additional information and knowledge. In case of dispute or any disagreement arises between the manufacturer and RDSO/CEE during the process of testing as regards the type test results, it shall be brought to the notice of the Director General (Traction Installation), RDSO/ CEE as the case may be, whose decision shall be final and binding.

9.1.4 In the event of the tests not being carried through to completion at one stretch for any reason attributable to the successful tenderer/ manufacturer and it is required for the representative of the purchaser/ Director General (Traction Installation), Research Designs And Standards Organisation, Lucknow, to go again or more number of times to the works of the successful tenderer/ manufacturer or other place(s) for continuing and/or completing the test on the prototype(s) of the equipment, the successful tenderer/ manufacturer shall reimburse to the purchaser/ Director General (Traction Installation), Research Designs & Standards Organisation, Lucknow, the cost of the representative having to visit the works or other place(s) for the test more than once. The cost as claimed by the purchaser/ Director General (Traction Installations),Research Designs & Standards Organization, Lucknow shall be paid through demand draft to the concerned accounts officer of the Purchaser/Director General (Traction Installation), Research Designs and Standards Organization, Lucknow, shall be advised to the successful tenderer manufacturer.

9.1.5 All type routine tests relevant to vectorial Delta I type fault selective relays shall be conducted as per the latest version of IEC-255-3, IEC-255-5, IEC-255-6, IS-3231 and IS: 8686 and as modified or amplified as under:

9.2 Type Tests :

9.2.1 Testing of characteristics

9.2.1.1 Fundamental and Operation Current Characteristic Test

The relay shall actuate on Vectorial Delta I current. The Vectorial Delta I current is the Vectorial difference between base current and fault current. The relay shall continuously sense the status of feeder protection relay through the MTR status and give trip command to the breaker only when these relays have failed to clear the fault. Relay shall also monitor the X value and shall ensure the operation of relay only if measured X value falls below the set value of X. blinder. The permissible error should be within +/- 7.5% of the set value.

Inject Vectorial Delta-I current to the relay and confirm the operation of the relay at different Vectorial Delta-I current settings. Voltage should be chosen accordingly so that the X range should falls below the set value. The permissible error should be within +/- 7.5% of the set value.

9.2.1.2 Vectorial Characteristic Test:

The relay shall consider phase angle difference between fault and base current and not only scalar values for its operation to discriminate between scalar Delta-I and vectorial Delta-I relay.

9.2.1.3 3rd Harmonic De-sensitivity Test

The relay shall be set at a particular value of V. Delta I current, and if the relay is fed with a distorted wave consisting of 150 Hz components with percentage more than 15% (+/-1.5) of 50 Hz., the relay should be operated at 200 % of the set value. The permissible error should be within +_ 7.5%. however, the base current is less than 5A.

9.2.1.4 2nd Harmonic Operation blocking Test.

The blocking (restraint) feature of the relay unit operation shall be confirmed when the second harmonic (100 Hz) content is 15% (+/-1.5) or more of fundamental (50 Hz) wave current.

9.2.1.5 X Range Monitoring Test

In X range monitoring test the relay should ensure the operation when the reactance (X) is below the set blinder value and the relay shall not operate when X is more than the set blinder value.

9.2.1.6 Operating Time Test.

The operating time between injecting of V.Delta I current in relay coil and change of relay contacts shall be measured with a timer at different setting.

9.2.1.7 Verification of operation of relay with X Blinder setting

The relay shall detect V.Delta-I and operate within operating time, if X value remains less. If X value becomes more than set X blinder, during operating time, then relay should block the trip command

9.2.2 Overload Capacity

No abnormality shall occur in any part of the relay when 10 times the rated current is passed through the relay for 3 second.

9.2.3 Rated consumption (VA) measuring test

Input voltage at the rated current should be measured. The rated VA shall be the voltage x current.

9.2.4 Rated Power Consumption Test

A rated voltage of 110 V dc as a power supply shall be applied to the relay unit and the load current of the relay unit shall be measured. The auxiliary power consumption shall be equal to 110 Volt dc X load current (dc) measured.

9.2.5 Making and Breaking Capacity of Contact Test

9.2.5.1 The contact of the relay shall withstand Make and Carry current of 30 A at 250 V a.c.50Hz for 3 Sec. There shall be no damage to the contacts of relay.

9.2.5.2 Breaking capacity: The contact of the relay shall withstand and break current of 5 A at 250 V a.c. (50Hz), Cos Ø 0.4 and 0.5 Amp at 220 V dc with load L/R = 45 milli Sec. There shall be no damage to the contacts of relay.

9.2.6 Temperature rise test

The temperature of each parts should be measured by thermometer after the rated current is passed through the relay continuously and temperature of each part becomes stable. The temperature limits of clause 8.6 should not be exceeded.

9.2.7 Insulation resistance test

Measure the insulation resistance ;between the voltage circuit, current circuit, circuit, contacts ;and terminals, and the case, with a 1000 V megger. It should be not less than 10 mega Ohms.

9.2.8 High Frequency Disturbance Test

The high frequency wave shall be given to the relay input circuit as per IS: 8686 in the following way.
i) Longitudinal mode – 2.5 kV, 1 MHz across auxiliary DC and current / voltage sensing terminal of the relay under test and to earth..
ii) Transverse Mode: - 1 kV, 1 MHz across DC input /voltage/current terminals..
The relay shall be subjected to this test for duration of 2 Seconds. When the characteristic quantity is fed, the relay shall not operate during the high frequency disturbance period. Further, the relay should remain stable during the test.

9.2.9 Impulse Voltage Withstand Test

3- impulse voltage waves (positive and negative each) of 5 kV peak and waveform 1.2 / 50 micro-Second as per IS 8686 shall be applied between all the terminal connected together and earth except the relay contacts. The relay should withstand this voltage.

9.2.10 Dielectric Strength

No abnormality should occur when AC 2 kV of power frequency for 1 minute is applied between the electrical circuits and the external case.

9.2.11 Operation Indication and reset of the relay

Indications of the operation must be clearly distinguishable and reset of the relay operates on fault should be possible from the front of the relay.

9.2.12 Vibration Test

The relay unit under test shall be subject to vibrations along each of its three major axis under the following conditions.

a. Vibration Frequency : 16.7 Hz
b. Amplitude of vibration : maximum amplitude 0.4 mm
c. Duration of each vibration: 10 minute each for back and forth, for right & left, and for up & down.

Malfunctioning of the output circuits contacts or otherwise shall be checked using a follower relay or device. The function of the follower relay /device is to indicate if the relay under test has malfunctioned by picking up or dropping off (dc). The follower relay response time shall be 0.3 ms or 10 ms. The relay under test shall be tested under energized and de -energized conditions.

9.2.13 Endurance Test.

The relays should be operated and reset 500 times repeatedly as per IS 3231 latest. No trouble should occur in any part of the relay.

9.2.14 Effect of Auxiliary Power Supply Variation

The terminals of the relay unit meant for connection to auxiliary power supply shall be fed with -30% of rated dc voltage i.e. 77V, rated voltage i.e. 110 V, and + 15% of the rated voltage i.e. 126.5V and relay operations shall be verified.

9.2.15 Heat Cycle Test

The Relay is to be kept in the Oven at 50°C for One Hour and at ambient room temperature at around 25°C for One Hour. This is to consist as One cycle of heating and cooling for the thermal stress.
The cycle is to be repeated for 5 (Five) times after which the relay operation shall be confirmed by injecting V.Delta-I current.

9.3 Routine Tests.

The following check and tests shall be carried out on each relay:-

i) visual inspection & dimensional check:
The relay shall be checked for general finish and dimensions as per approved drawing.

ii) All the test mentioned in clause 9.2.1 and 9.2.7 of this specification shall be carried out.

10.0 RATING PLATE

10.1 The rating plate shall contain the following information:

1. Name and Type
2. Rated current
3. Rated frequency.
4. Rated control voltage
5. Second harmonic lock
6. Third harmonic de-sensitization.
7. Year and month of manufacture
8. Manufacture number
9. Name or abbreviation of manufacturer.

11.0 ERECTION AND COMMISSIONING TESTS

11.1 The erection and commissioning of relay shall be done by the successful tenderer who shall arrange all tools , plants , instruments and other material required for the purpose at his own cost. Tests shall be carried out during erection/commissioning of the relay at the site. The successful tenderer shall be required to submit to the purchaser the details of the checks and tests to be carried out during erection and commissioning. Tests shall be carried out on the relay in the presence of the purchaser's representatives to check the erection and commissioning of the relay.

11.2 Three sets of the test report shall be supplied by the manufacturer to the purchaser for records and reference.

11.3 On satisfactory commissioning of the relay the tenderer shall advise RDSO also regarding the commissioning of all such relays during the field validation period.

12.0 TECHNICAL DATA AND DRAWINGS

12.1 The tenderer shall furnish guaranteed performance data, technical and other particulars for the equipment offered in the proforma attached as Annexure-4.

12.2 The tenderer shall furnish their compliance or otherwise against each clause/sub-clause of the technical specification. If the tenderer wishes to deviate from the provision of any clause/sub -clause, he shall furnish the full details with justification for such deviation.

12.3 The tenderer shall also furnish descriptive pamphlets and specimen calculations for the recommended relay setting. The range of setting available, calibrated in terms of single track OHE, shall be clearly stated and adjustments available for intermediate setting explained.

12.4 Successful tenderer shall be required to submit detailed outline dimensioned drawings and cut out drawings for the equipment offered as per railways standard in sizes of 210 mm x 297 mm or any integral multiple thereof.

13.0 OPERATION , MAINTENANCE INSTRUCTIONS & TRAINING

13.1 The relay shall be a maintenance free relay generally not needing any maintenance, however the tenderer shall mention a maintenance schedule which shall be detailed enough to guarantee failure free service of the relay to the tenderer. The supplier shall supply free of cost 2 copies to the consignee of the Instruction Manuals for operation and maintenance of the equipment. The manuals shall contain full particulars of various functions, full dimensioned drawings and circuit diagrams.

13.2. The tenderer shall train free of cost 2 of the associated engineers/supervisors for 7 days in the maintenance, operation, relay setting procedure, trouble shooting and commissioning of the relay. This training shall be 3 days at manufacturer works and four days at the relay installation site.

13.3 The tenderer shall quote separately for maintenance tool, kits and test instruments if any required for satisfactory operation of the relay . The tenderer shall quote for spares required for the relay for 5 years of trouble free operation beyond the warranty period. The purchaser reserves the right to buy the kit from the tenderer or not.

13.4 The Successful tenderer shall develop a maintenance schedule and a trouble shooting chart for effective , reliable and trouble free relay operation. The basic maintenance schedule along with the troubleshooting , diagnostic chart shall be submitted to RDSO and approved by RDSO prior to commissioning of the relay for the first time at the site.

13.5 All correspondence regarding the relay during the limited use period (i.e. the till the field validation is completed) between the zonal railways the manufacturer shall be given to RDSO for judging the extent of problems on the relay.

14.0 WARRANTY

14.1 The relay supplied against a purchase order/contract in which this specification is quoted, irrespective of origin individual equipment (imported / indigenous) shall be guaranteed for trouble - free and satisfactory performance for a period of 18 months from the date of supply or 12 months from the date of commissioning, whichever period is earlier, details of warranty clause, the extent of responsibility and other relevant aspects shall be included in the purchase order or the contract. The tenderer shall furnish detailed terms and conditions in this regard in his offer.

14.2 The successful tenderer shall make necessary arrangement for closely monitoring the performance of the relay through periodical (preferably once in four months during the warranty period) visits to the relay installation TSS for on the spot detailed observations. Arrangements shall be also be made for spare parts modules and other items to be kept readily available with the manufacturer/ supplier / successful tenderer to meet exigencies warranting replacement so as to put back the relay in service without unduly affecting the operations of the TSS.

A N N E X U R E 1

L I S T O F A B B R E V I A T I O N S

Abbreviation	**Full Form of the Abbreviation**
A	Amperes
BT	Booster Transformer
GTO	Gate Turn Off Thyristors
IDMT	Inverse Definite Minimum Time lag
IOL	Insulated Overlap
LCD	Liquid crystal diode
LED	Light emitting diode
MSG	Maintenance Study Group.
MTBF	Mean Time Between Failure
NC	Normally closed.
NO	Normally open
OHE	Over Head Equipment
RC	Return Conductors.
SP	Sectioning Post
SR	Self Reset
SSP	Sub Sectioning Post
TrD	Traction Distribution
TRS	Traction Rolling stock
TSS	Traction Sub Stations

Item	Definition
Tenderer	The vendor , supplier who intends to quote for the tender floated by the purchaser. The agency who shall quote for tender floated by the tenderer.
Purchaser	The person / agency who has floated the tender for execution of the work on or behalf of the president of India.
Relay	Vectorial Delta I relay
Delta I current	In fluctuating current, delta I current is the portion of current which increases .
Vectorial Delta I current	It is vectorial difference between base load current and the fault current.
Base current	In fluctuating current, the base current is the current value immediately preceding the increase.
Second harmonic lock	Second harmonic lock is the locking operation of the relay when the second harmonic components become large
Operation time	Period of time from a fault occurs till the output- contact of the relay closes.
Third harmonic suppression	Third harmonic suppression is the suppression of the sensitivity of the relay by third harmonic components
Making capacity	The maximum current and volt -amperes the contact is able to make successfully under specified conditions without significant damage to the contact.
Breaking capacity	The maximum current and volt - amperes that the contact is able to interrupt successfully under specified conditions without significant damage to contact.
Normally open contact (NO)	A contact which is open when the relay is de-energised.
Normally closed contact (NC)	A contact which is closed when the relay is de-energised.
Contract	Means the contract resulting from the acceptance by the purchaser of the tender either in whole or part
Equipment	Means all or any equipment considered necessary by the purchaser engineers for the satisfactory operation as a whole of the installation including structure, foundations etc.
Railway	Means Railway(s) in whose territorial jurisdiction the work is to be carried out and includes the Government of India, Ministry of Railways (Railway Board), and /or general manager of the railways concerned

G O V E R N I N G S P E C I F I C A T I O N S

The Delta I relays and components thereof shall , unless otherwise specified shall conform to generally to the latest edition of Specifications mentioned below:

IEC 255 -3	Single input energising quantity measuring relays with dependent or independent time. independent time
IEC 255-5	Insulation tests for electrical relays
IEC 255 -6	Measuring relays and protection equipment.
IS-2705 (Pt.III)	Protective current transformers
IS 3231	Electrical relays for power system protection
IS 8686	Static protective relays
RDSO spec ETI/PSI/65(1/97)	Control and relay panel for 25 kV ac traction system.
Iis 3156	Protective Potential Transformer

The above specifications shall be applied in a manner altered, amended or supplemented by this specification and the latest Indian Electricity Rules wherever applicable.

Any deviations from the specifications proposed by the tenderer at the tender/prototype stage, to improve the performance, utility or efficiency of the equipment shall be given due consideration provided full details of the deviation are furnished by the tenderer to the satisfaction of the purchaser. In such cases the tenderer shall quote according to the specification as well as with the deviations from the specifications.

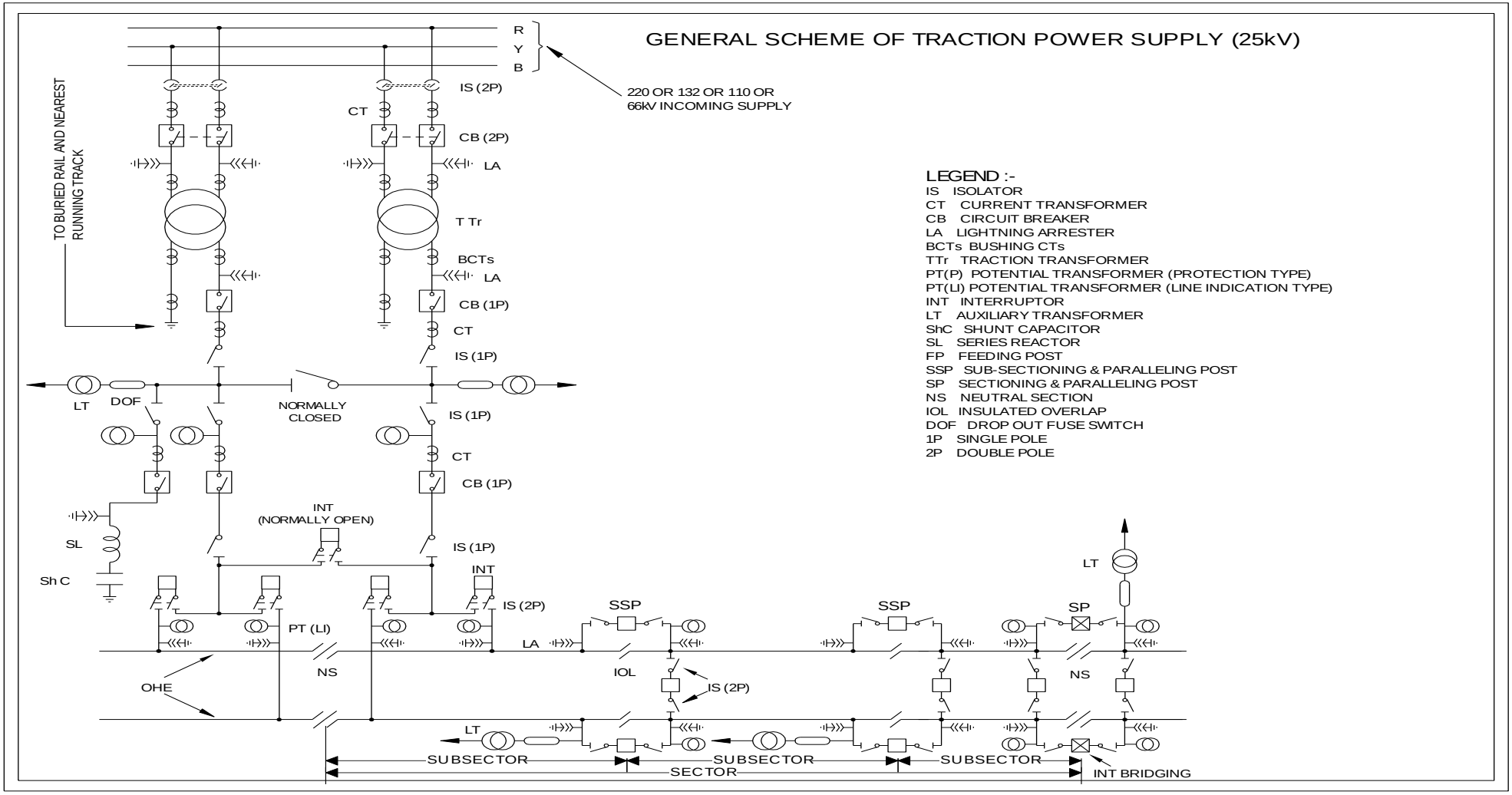
ANNEXURE 4

SCHEDULE OF GURANTEED PERFORMANCE

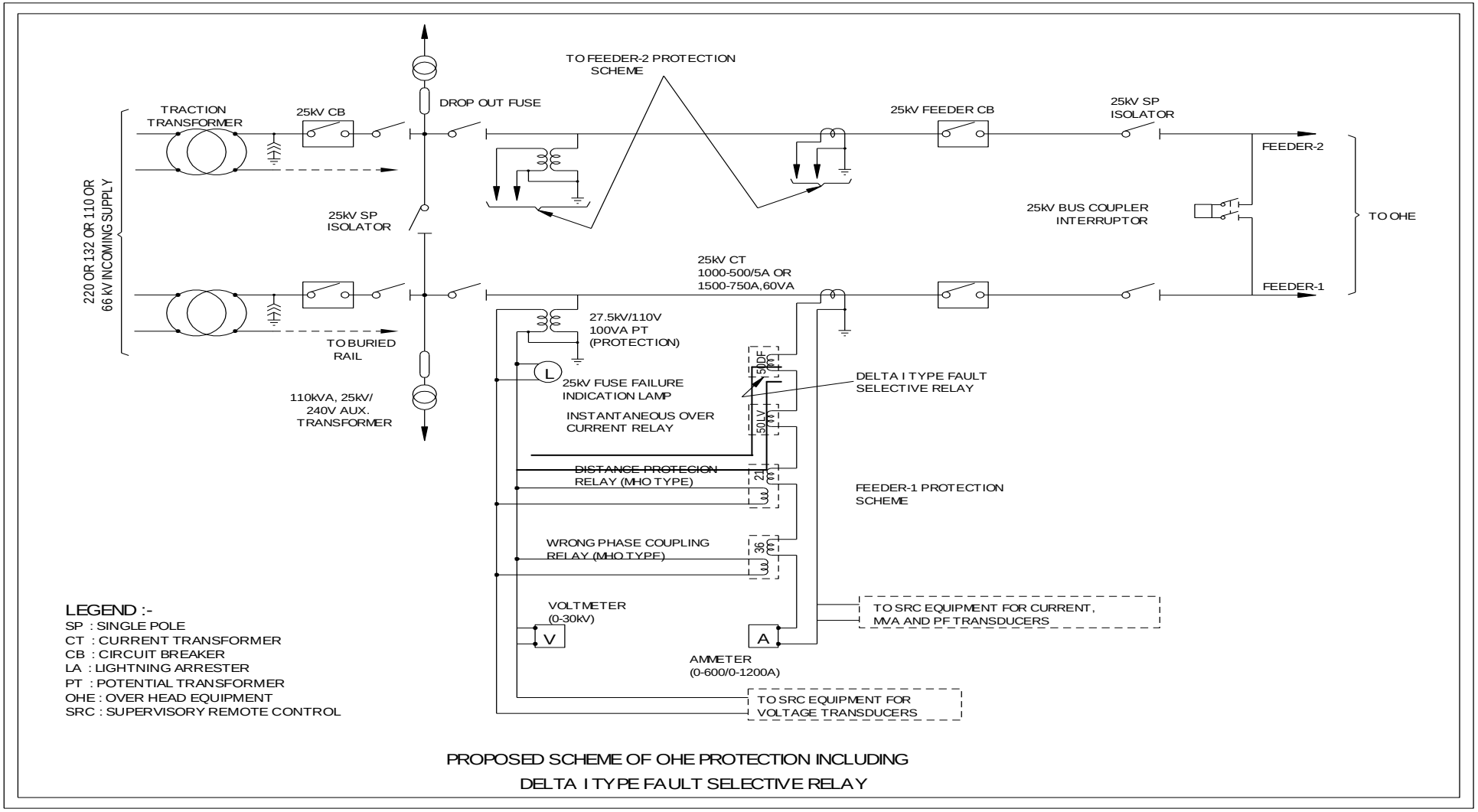
S.No.	Description	Manufacturer details	Unit of measurement
1	Name of the manufacturer		
2	Country of origin		
3	Standard governing specification		
4	Manufacturer's type designation		
5	Rated current		Amps
6	Setting range		Amps
7	Rated frequency		Hz
8	Permissible variation in frequency		%
9	X Blinder setting range		ohm
10	Error in X blinder setting		%
11	Rated short time current for 1 sec.		Amps
12	Rated dynamic current		Amps
13	Operating time (a) Normal		milli-sec
14	(b) With timer		milli-sec
15	Rated VA burden		VA
16	Power consumption of control circuit		Watts
17	Maximum percentage error		%
18	Maximum arc resistance that the relay can identify		Ohm
19	Resetting time		milli-sec
20	Rated current carrying capacity of contacts		Amps
21	Rated breaking capacity of contact		Amps
22	Rated making capacity of contact		Amps
23	Number of spare No and NC contacts		
24	Temperature rise at rated current		^{o} C
25	Is the relay draw out type?	Yes/No	
26	Are test terminals/test switches provided?	Yes/No.	
27	Have specimen calculations for the recommended relay setting been enclosed with the offer ?	Yes/No.	

28	Rated making & breaking capacity of contacts		Amps
29	Rated D.C. voltage variation range for which relay operation is guaranteed		Volts
30	Rated relay voltage for the D.C. circuit		Volts
31	Rated relay current for the D.C. circuit		Amps
32	Number of spare No and NC contacts		
33	Are test terminals /test switches provided ?	Yes/No.	
34	Have specimen calculations for the recommended relay setting been enclosed with the offer ?	Yes/No.	
35	Dimensions:		
36	Length		mm
37	Width		mm
38	Breadth		mm
39	Weight of the relay		grams
40	Rated Vibration withstand		microns

ANNEXURE 5 General Scheme Of Power Supply For 25 Kv AC System



ANNEXURE 6 General Scheme Of Protection For 25 Kv AC System



PROPOSED SCHEME OF OHE PROTECTION INCLUDING
DELTA I TYPE FAULT SELECTIVE RELAY