

# ANDHRA PRADESH CODE OF TECHNICAL INTERFACE

## Section 3

### CONNECTION CODE

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## CONNECTION CODE

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### 3.1 Procedure For Application For Connection

#### 3.1.1 Users

Any **User** seeking to establish new or modified arrangements for **Connection** to and/or use of the **Transmission System** shall follow the procedures laid out in this Code.

#### 3.1.2 Licensee

The **Licensee (APTRANSCO)** shall follow the procedures and time limits specified in this Code in processing the application, making or modifying an offer and rejecting an offer.

#### 3.1.3 Optimal Connection Locations

APTRANSCO shall publish annually before 31<sup>st</sup> March, a list of points which are technically optimal connection locations where generators and suppliers can connect their systems to APTRANSCO system.

#### 3.1.4 Data from APTRANSCO

Any prospective user or existing user wishing capacity enhancement may after studying the Long Term Plan and the Statement of Opportunity published by APTRANSCO may request APTRANSCO for more information. APTRANSCO shall furnish the data required within 15 days of requisition. APTRANSCO may refuse to furnish the data if it considers the data is confidential and is not required for the business of the prospective user. APTRANSCO may charge reasonable cost for supplying the data.

#### 3.1.5 Application for Connection

Any User seeking use of the Transmission system may submit an Application for connection to APTRANSCO in Format developed by APTRANSCO.

#### 3.1.6 Acceptance or Rejection

APTRANSCO shall either accept or reject the application within 30 days from the date of Application. If rejected, APTRANSCO shall communicate the reasons. If APTRANSCO requires additional data from the Applicant the last date for acceptance or rejection may be extended by another month from the date of submission of the additional information. The additional data shall be furnished to APTRANSCO within 15 days from the date requisitioned. If the additional information is not received by APTRANSCO within 15 days, it can either reject the Application or extend the date.

#### 3.1.7 Connection Agreement

If the Application is accepted then APTRANSCO and the user shall proceed to finalise a Connection

Agreement as per para 3.2.3.

### **3.1.8 Data Exchange**

The data exchange between APTRANSCO and users shall be in accordance with the provisions of the Planning code.

### **3.1.9 Non-Acceptable Offers**

In the event of the offer becoming invalid or not being accepted by any **User** within the validity period, no further action shall be taken by the **APTRANSCO** on the **Connection** applications.

## **3.2 Connection Conditions**

### **3.2.1 Introduction**

**Connection Conditions** specify the technical, design and operational criteria which must be complied with by any **User** connected to the **Transmission System**.

### **3.2.2 Objectives**

The objective of this Section is to ensure the following:

- (i) All **Users** or prospective **Users** are treated equitably.
- (ii) Any new **Connection** shall not impose any adverse effects on existing **Users**, nor shall a new **Connection** suffer adversely due to existing **Users**.
- (iii) By specifying minimum design and operational criteria, to assist **Users** in their requirement to comply with **License** obligations and hence ensure that a system of acceptable quality is maintained.
- (iv) The ownership and responsibility for all items of equipment is clearly specified in a schedule (Site Responsibility Schedule) for every site where a **Connection** is made.

### **3.2.3 Connection Agreements**

A Connection Agreement shall be drawn up specifying the general conditions for connection and any specific conditions, both technical and financial, applicable to that connection.

If the design parameters based on which the original offer was made, have changed, **APTRANSCO** shall make a revised offer to the User including revised terms and extended time limit for submission of data. This revised offer shall form the basis of any Connection Agreement.

### **3.2.4 Connection Site Matters**

#### **3.2.4.1 Site Responsibility Schedule**

For every **Connection** to the **Transmission System** for which a **Connection Agreement** is required, a schedule of equipment shall be prepared by **APTRANSCO** with information supplied by the respective **Users**. This shall include:

- Schedule of HV Apparatus
- Schedule of Plant, LV/MV Apparatus, services and supplies
- Schedule of telecommunications and measurements Apparatus
- The safety rules which apply to each Plant/Apparatus

A Site responsibility Schedule, shall state the following for each item of equipment installed at the **Connection Site**:

- (i) The ownership of equipment.

- (ii) The responsibility for control of equipment.
- (iii) The responsibility for maintenance of equipment.
- (iv) The responsibility for operation of equipment.
- (v) The manager of the site.
- (vi) The responsibility for all matters relating to safety of persons at site.
- (vii) The responsibility for all matters relating to safety of equipment at site.

All H.V. Apparatus on any connection site shall be shown on one diagram which shall include details of the following.

1. Bus bars
2. Circuit Breakers
3. Isolators
4. Bypass facilities
5. Earthing switches
6. Maintenance of Earths
7. Overhead line entries
8. Overhead line tappings
9. Cable and Cable Sealing ends
10. Generating Unit
11. Generating Unit Transformers
12. Generation unit auxiliary transformers including lower voltage circuit breakers
13. Station Service Transformers including lower voltage circuit breakers
14. Capacitors including synchronous compensators
15. Series and shunt reactors.
16. Grid Transformers (Inter Connecting transformers)
17. Tertiary windings
18. Earthing and Auxiliary Transformers
19. 3 $\phi$  Voltage transformers
20. 1 $\phi$  Voltage transformers with phase identity
21. Surge Arresters
22. Neutral earthing arrangements on HV plant
23. Current transformers

The **User** owning the **Connection** site shall provide reasonable access and other required facilities to another **User** whose equipment is installed at the **Connection** site for installation, operation and maintenance, etc.

Each Connection point shall be precisely shown.

An illustrative Site Responsibility Schedule is provided in the Appendix to this Section.

#### 3.2.4.2 Site Common Drawings

Site Common Drawings shall be prepared by the owner Company (APTRANSCO or Users) using the information furnished by the other Company (User or APTRANSCO) containing the following information:

- (i) Connection Site Equipment layout
- (ii) Electrical Layout

- (iii) Common Protection and Controls
- (iv) Common Services.

SCDs are updated by the request and initiation of either company but the responsibility of updating at every change lies with the site owner.

#### 3.2.4.3 Maintenance at Connection Site

The User's equipment at the APTRANSCO's site shall be maintained promptly and properly by the User and vice versa so that the equipment and personnel of the site owner are not jeopardised by the neglect of the other Company.

#### 3.2.4.4 Site Operational Procedures

APTRANSCO and User must make available staff to take necessary safety precautions and carry out operational duties at the Site. The written operating and safety instructions must be available at the site.

### 3.2.5 System Performance

- (a) All equipment connected to the **Transmission System** shall be of such design and construction as to satisfy the requirements of the relevant Indian Standard Specification. Where no BIS exists, the appropriate IEC Standard or equivalent International Standard will apply.
- (b) Installation of all electrical equipment shall comply with **IE Rules**
- (c) For every new **Connection** sought, the APTRANSCO shall specify the **Connection Point** and the voltage to be used, along with the metering and protection requirements as specified in the Metering and Protection Sections.
- (d) The **Transmission System** frequency shall be in accordance with the Grid Characteristics Section. The **User** shall however be subject to the grid discipline prescribed by **SLDC/ SRLDC** as per guidelines mutually agreed with **SREB/ SRLDC**.
- (e) Voltage variation on the **Transmission System** shall be in accordance with the Grid Characteristics Section.
- (f) Insulation co-ordination of the **Users'** equipment shall conform to applicable Indian Standards/Codes. Rupturing capacity of switchgear shall not be less than that specified by **APTRANSCO**.
- (g) Protection and Metering schemes shall be as detailed in the Protection Section of the **Code**.  
For existing **Power Stations**, the equipment for data transmission and communications shall be owned and maintained by the **APTRANSCO**, unless alternative arrangements are mutually agreed.  
For new **Power Stations** the equipment for data transmission and communications shall be owned and maintained by the respective **Generator**.
- (h) The new Generating units to be connected to the Grid shall be capable of increasing the output by 5% instantaneously upto 105% MCR for a minimum of 5 minutes.
- (i) The new Generating units shall have AVR and turbine speed governor with overall droop of 3 to 6%.

### 3.2.6 Connection Point

### 3.2.6.1 Generator

Voltage may be 400/220/132 kV or as agreed with the **APTRANSCO**.

Unless specifically agreed with the **APTRANSCO**:

- The **Connection Point** shall be the **first takeoff tower from the Power Station switchyard** which is the boundary between **GENCO** and **APTRANSCO**

The **Tariff Metering Point** shall be **between the synchronising breaker and the EHT bus on the HV side of the Generator Transformer**, or each feeder, i.e., between the feeder breaker and the line isolator of the feeder.

All equipment, including metering, protection and communication up to the **GENCO-TRANSCO** boundary shall be maintained by the **Generator**, and all equipment beyond the Boundary (towards the line) shall be maintained by **APTRANSCO**.

### 3.2.6.2 Distribution Company

Voltage may be 33/11 kV or as agreed with the **APTRANSCO**. All 33 kV lines and below shall be under the jurisdiction of the **DISCOMs**. All lines and network above 33 kV shall be under the jurisdiction of **APTRANSCO**.

- The **Connection Point** shall be the **first take off pole of the 33 or 11 kV feeder** which is the boundary between **APTRANSCO** and **DISCOMs**. Alternatively the outgoing terminals of the Line Isolator of the 33 kV or 11 kV Feeder.
- The **Tariff Metering Point** shall be **between the LV Breaker of the Power Transformer and the LV bus isolator**.

All equipment, including metering, protection and communication on the transformer side of the Boundary shall be maintained by **APTRANSCO**, and all equipment beyond the Boundary shall be maintained by **DISCOMs**.

All HT services including EHT services such as 132 kV and 220 kV shall be with **DISCOMs** as per geographical jurisdiction.

### 3.2.6.3 CPPs & Bulk Power Consumers

Voltage may be 220/132/33 kV or as agreed with the **APTRANSCO**.

Sub-stations are owned by **CPPs** and **Bulk Power Consumers**. The **Connection Point** shall be the feeder gantry in their premises.

### 3.2.7 Data Requirements

**Users** shall provide the **APTRANSCO** with data for purposes of this **Section** as specified in the Annexures to Planning Code and as requisitioned by **APTRANSCO**.

### 3.3 Under Frequency Relays

The **DISCOMs** shall install low frequency relays at various locations to shed load when frequency falls. **APTRANSCO** and **DISCOMs** shall enter into Agreements regarding the amount of load in MW to be shed at different values of low frequency. The location at which loads are to be disconnected shall be decided by the **DISCOM**. The specifications of the low frequency relays are given in Appendix B. The **LT AC** power supply to the Low Frequency Relays shall be derived from the primary supply i.e, Station

Auxiliary Transformer but not from the external public distribution system.

### **3.4 Grid Characteristics**

#### **3.4.1 Introduction**

This section specifies the electrical parameters of performance of the GRID which affect the performance of connected Users and other transmission systems interconnected with the AP Transmission Grid.

#### **3.4.2 Objective**

- (i) To ensure that the GRID performance meets a minimum standard which is essential for the Users' system and equipment to function properly.
- (ii) To enable Users to design their systems and equipment to suit the electrical environment that they operate in.
- (iii) To enhance the quality standards of the AP Electrical System towards standards stipulated in or established under the authority of National and State Acts and Rules in the short term and gradually moving towards international standards in the long term.

#### **3.4.3 Implementation**

The GRID performance standards established herein shall be implemented in a manner so as to ensure that no entities are forced to achieve goals beyond the capability and limitations of the current system in the immediate future while continuing to strive for the higher standards by improving their system in the long term.

To this end, the CTI shall be implemented in three Stages:

##### Preliminary Stage:

The time period immediately following approval of the first version of the CTI by APERC. Existing conditions to prevail. However all entities shall endeavour to minimise the duration of the Preliminary Stage.

##### Transition Stage:

An agreed time period during which improvements are made to the system with the injection of investment capital.

##### Final Stage:

An agreed time period when substantial improvements have been carried out and the system is considered to be in satisfactory condition with the needed capital investment.

Standards for different Stages will be different.

The length of the Preliminary Stage and Transition Stage shall be determined by the Regulator who will inform all parties concerned of impending change to the next stage at least six months in advance.

#### **3.4.4 Voltage Criteria**

The voltage criteria detailed below are the target values to be achieved under the leadership of **APTRANSCO**, in coordination with SRLDC and with the cooperation of the Power Sector Utilities in Andhra Pradesh State.

##### *3.4.4.1 Voltage Variations (CEA Standards)*



System Voltage	Maximum (RMS)	Minimum (RMS)
400 kV	420 kV	360 kV
220 kV	245 kV	200 kV
132 kV	145 kV	120 kV

#### 3.4.4.2 Voltage Unbalance

The phase voltages of a 3-phase supply should be of equal magnitude and 120° apart in phase angle. Deviations will result in decreased efficiency, negative torque, vibrations and overheating. Severe unbalance could lead to malfunctioning of some equipment. Voltage unbalance is defined as:

$$\text{Voltage Unbalance} = \frac{\text{Deviation between highest and lowest phases}}{\text{Average voltage of three phases}}$$

Limits for voltage unbalance are:

220kV and above: 2%

Below 220 kV: 3%

Balancing loads on individual phases will help greatly in avoiding unbalanced voltages

#### 3.4.5 Frequency

Frequency of the transmission system should be maintained within an acceptable range to ensure proper operation of the system. Insofar as possible, APTRANSCO shall fulfil its partial responsibility to enable SRLDC to keep the frequency within acceptable ranges and avoid the periods where the frequency values given under “Extreme Conditions” prevail.

**TABLE**

**Frequency Limits**

<b>SREB Standards : “targets” to be achieved:</b>	
Upper limit:	50.5 Hz
Lower limit	49.5 Hz
<b>Statutory Limits : acceptable</b>	
Upper limit:	51.5 Hz
<b>Lower limit:</b>	48.5 Hz
<b>Extreme Conditions:</b>	
Upper limit:	52.5 Hz
Lower limit	47.5 Hz

3.4.5.1 All new generating units shall be capable of operation in 47.5 to 51.0 Hz frequency range for short duration without damage or reduction of life.

### 3.4.6 Reliability Criteria

System reliability of the GRID includes three aspects:

- system adequacy
- system security.
- service reliability

#### 3.4.6.1 Generation Adequacy

Adequacy is the ability of the electric system to supply the aggregate electrical demand and energy requirements of their customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

Adequacy of the generating system is usually measured in terms of loss of load probability (LOLP) which is the probability of system capacity not being able to meet system load. LOLP can also be expressed as loss of load expectation (LOLE) in days per year. This measure does not consider the amount or duration of the capacity shortfall.

##### System Adequacy Limits:

Preliminary Stage:	20%
Transition Stage:	8%
Final Stage:	1% (87.6 hr/year)

#### 3.4.6.2 Security

Security is the ability of the electric system to withstand sudden disturbances such as electric short circuits or unanticipated loss of system elements.

The bulk electric system shall be designed for a security level of n-1, i.e. to withstand a single contingency with little negative effect. This means the most severe fault or the tripping of a critical generator, transformer or line should not result in

- a) instability of the system
- b) overloading lines and/or transformers for more than 15 minutes
- c) voltage drop of more than 10 % when the system import is increased by 20%
- d) load shedding

##### System Security Limits:

Security level of “n-1” (single contingency) **PLUS**  
spinning reserve margin of:

Preliminary Stage:	no mandatory requirement
Transition Stage:	0.5 % of system peak load
Final Stage:	1 % of system peak load

#### 3.4.6.3 Service Reliability

The points where electric power is supplied from the transmission system to the **Users** (distribution companies, another transmission system, EHT customers) are called delivery points or grid supply points. Outages at these points directly affect the **Users** of the GRID. The reliability level at the delivery points is therefore an indication of the quality of service provided by **APTRANSCO** to its Users.

Service reliability of the GRID is indicated by :

System Average Interruption Frequency Index (**SAIFI**)

System Average Interruption duration Index (**SAIDI**)

which are calculated as follows:

For each forced outage involving one or more delivery points and lasting more than 1 minute, the following parameters are recorded:

- Duration of outage in minutes: **T<sub>i</sub> (min)**
- Sum of interrupted loads at all affected delivery points: **Σ P<sub>i</sub> (kVA)**

$$SAIFI = \frac{\sum P_i}{P_{total}}$$

$$SAIDI = \frac{\sum (P_i \times T_i)}{P_{total} \div 60}$$

Where P<sub>total</sub> = total sum of installed load at all delivery points

**Note:** Scheduled outages which are communicated to the consumers beforehand and load shedding due to capacity shortage are not counted in the computation of these indices

#### Allowable Limits

	SAIFI	SAIDI
Preliminary Stage	no limit	no limit
Transition Stage	24/yr	10 hours/year
Final Stage	18/yr	8 hours / year

### 3.4.7 Harmonic Distortion

#### 3.4.7.1 General Description

Many types of equipment and phenomena can produce voltages and currents at frequencies that are multiples of the power frequency. These high frequency components are called harmonics and their ratio to the fundamental frequency is the harmonic order. Harmonics have many negative effects on the system and connected loads, so they have to be limited to a manageable level.

Control of harmonics on the **APTRANSCO** system is based on voltage harmonic distortion. Users produce harmonics by drawing from and injecting into the system harmonic currents which propagate through the system creating harmonic voltage drops, thus affecting others, so control of User harmonics is based on harmonic distortion current.

Harmonics are grouped into three categories: odd triplens (multiples of three), other odd harmonics, and even harmonics, with different severity levels and effects on equipment for each category. Odd harmonics are much more common than even harmonics.

#### 3.4.7.2 Indicator of Quality for System Harmonics

Harmonic contents of the supply voltage is indicated by the following indices:

$$V_{THD} = \sqrt{\sum_{i=1}^{40} \frac{V_i^2}{V_1^2}} \times 100\%$$

$$V_{IHD} = \frac{V_i}{V_1} \times 100\%$$

Where  $V_i$  : ith harmonic of voltage

$V_1$  : fundamental frequency (50 Hz) voltage

$V_{THD}$ : voltage total harmonic distortion

$V_{IHD}$  : voltage distortion of ith harmonic

### 3.4.7.3 Maximum Limits of Voltage Harmonic Distortion in HT and EHT Systems.

**Table**

Harmonic Order	Distortion %	
	HT	EHT
(odd, non-triplen)		
5	6.0	2.0
7	5.0	2.0
11	3.5	1.5
13	3.0	1.5
17	2.0	1.0
19	1.5	1.0
23	1.5	1.0
25	1.5	0.7
>25	$0.2+1.3 \times 25/n$	$0.1+0.6 \times 25/n$
(odd, triplen)		
3	5.0	2.0
9	1.5	1.0
15	0.3	0.3
21	0.3	0.2
>21	0.2	0.2
(even)		
2	2.0	2.0
4	1.0	2.0
6	0.5	0.5
8	0.5	0.4
10	0.5	0.4
12	0.2	0.2
>12	0.2	0.2
Total Harmonic Distortion	8%	3%

### 3.4.7.4 Control and Measurement

(a) Control

**APTRANSCO** shall monitor the voltage harmonic levels at the supply points to the Users (**DISCOMs**, **AP Genco**, major users) and other strategic locations on the transmission system.

**APTRANSCO** will compile a list of all metering points and take measurements at 5 sites per month. The list has to be submitted to APERC for approval.

(b) Measurement

The measurements should conform to IEC Std 1000-4-7 or IEEE Std 519. The measurements should be taken at 10 minute intervals and should last for 1 week per site.

*3.4.7.5 Enforcement of Limits*

The harmonic voltage limits will be implemented in stages as follows

Preliminary Stage

Limits not in effect

Transition Stage

**APTRANSCO** will monitor voltage harmonic distortions at all delivery points, but no sanctions will apply for exceeding the limits

Final Stage

The limits in Section 3.4.7.3 will apply

Limits of Supply Voltage Harmonics in LT System will be included in future Versions.

**3.4.8 Voltage Flicker***3.4.8.1 General Description*

If the voltage fluctuates, the luminous intensity of the lamps and TV's will fluctuate correspondingly. If the fluctuation is of a magnitude and frequency perceptible to the eye, it becomes flicker. Flicker could range from annoying to complete interference of normal activity.

Flicker is not usually produced by the power system but by customer loads such as arc furnaces, compressors, starting of large motors, etc. Since voltage fluctuation of the system affects other users on the same system, the transmission company needs to control the flicker on its lines and station busses. At the same time, flicker-generating loads connected to the system have to be controlled.

*3.4.8.2 Indicator of Quality for System Flicker*

Flicker is measured by means of two indices,  $P_{St}$  and  $P_{It}$ , as defined in IEC Std 1000-3-7. For the purpose of regulation,  $P_{St}$ , the short term flicker severity index, is selected as the indicator of quality.

*3.4.8.3 Limits*

$P_{St} = 1$ , which is equivalent to the threshold of perception, is the allowable level of flicker on the transmission system.

#### *3.4.8.4 Control and Measurement*

Substations which supply heavy industrial loads such as furnaces, steel mills, etc. are targets for flicker monitoring. Other substations and connection points will be selected for monitoring on a random basis. At least one site is monitored each month.

The list of monitoring points is submitted to APERC for approval at least 2 months before the monitoring. The flicker measurement will be conducted at 10 minute intervals according to procedures outlined in IEC Std 61000-4-15. Each site is measured for 1 week

#### *3.4.8.5 Enforcement of Limits*

Flicker limits and control and measurement procedure will be in effect only in the Final Stage

### **3.5 Connected Plant Restrictions**

#### **3.5.1 General Principle**

Users connected to the Grid can produce power disturbances which propagate to the power system. If these disturbances are severe, the power system and other Users on the system will be adversely affected. To ensure system integrity and fairness to all Users restrictions and controls have to be placed on Users of the system.

#### **3.5.2 Safety**

The term "Safety" refers to safety standards adopted in manufacture, erection stages in choice of location and in installation, operation and maintenance procedures. The term applies both to safety to equipment and safety to persons including safety of general public (in addition to safety of utility staff).

The equipment of the Users, including machines, devices, overhead lines, underground cables, transformers, etc., must conform to Safety Standards (ISS, general engineering safety standards and the safety Codes to be issued by **APTRANSCO**). The Standards of the Safety Codes to be issued by **APTRANSCO** shall not be lower than, or inferior to, the APSEB Safety Manual.

#### **3.5.3 Insulation**

The Users' system must be designed with the proper basic insulation level (BIL). Insulation of all components in service must have adequate dielectric strength for the system operating voltages at all times.

#### **3.5.4 Clearances**

All overhead lines, equipment and facilities of the User's system connected to the GRID must comply with clearance limits published in the Indian Electricity Rules. For situations not covered in the Indian Electricity Rules, the IEEE C2-1997 "National Electrical Safety Code" will apply.

#### **3.5.5 Earthing**

All components of the Users' systems must be properly earthed as per standards. All individual earth electrodes, earthing pits, and the interconnection arrangements shall be as per standards and shall be properly maintained.

The bodies/cases/trucks/enclosures of all items of equipment shall be properly earthed, with the actual earthing arrangements depending on the machine ratings. Metallic supports of overhead lines and cable

sheaths and shields shall also be earthed as appropriate.

### 3.5.6 *Safety Training*

Personnel of all entities shall be adequately trained in the correct operating techniques and safety precautions, keeping in mind cross-boundary connections.

### 3.5.7 *Motor Starting*

The Motor Starting Current of motors in the Users' systems shall be less than 6 times the full-load current unless special exemption is granted. The appropriate methods of motor starting shall be adopted. Two or more motors shall not be started simultaneously or within 5 minutes if the resulting voltage dip at the substation bus exceeds 5 %.

Where necessary, **APTRANSCO** shall have the right to advise the consumer or User to change over to "auto-transformer" motor starting if the existing starting method causes unacceptable system distortions.

### 3.5.8 *Access to APTRANSCO*

**APTRANSCO** and its authorized personnel shall have the right to inspect the plant of any USER or Consumer, to ensure conformity to standards and restrictions.

### 3.5.9 *Unintended and Unscheduled back-energization*

The Users shall take adequate precautions to ensure that no part of the grid is energized by the Users' system from another source of supply unless it is requisitioned in writing by the utility as an exceptional arrangement. The switch-gear and controls of the Users' systems shall be so designed as to prevent back-energisation and the personnel shall be made aware of the need for this precaution.

### 3.5.10 *Harmonics (Harmonic Current Generated by Consumers)*

#### 3.5.10.1 *Indicators*

The level of harmonics generated by Users or customers is indicated by the percentage of harmonic distortion measured at the point of connection. The following indices are the total current harmonic distortion and the individual current harmonic distortion respectively.

$$I_{THD} = \sqrt{\frac{\sum I_i^2}{I_1^2}} \times 100\%$$

$$I_{IHD} = \frac{I_i}{I_1} \times 100\%$$

where:

$I_{THD}$  = Total harmonic distortion of current

$I_{IHD}$  = Individual distortion of current of harmonic order  $i$

$I_i$  = Current component of harmonic order " $i$ ";  $I_1$  = Current component of fundamental frequency 50 (HZ)

#### 3.5.10.2 *Limits*

Limits of Harmonic Current Distortion (%)

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Harmonic Order (n)	P > 10 kW or V < 33 kV	P > 50 kW or V > 33 kV
Odd, Non triplen		
5	12	6
7	8.5	5.1
11	4.3	2.2
13	3	2.2
17	2.7	1.8
19	1.9	1.7
23	1.6	1.1
25	1.6	1.1
>25	$0.8+0.8*25/n$	0.4

Triplen		
3	16.6	7.5
9	2.2	2.2
15	0.6	0.8
21	0.4	0.4
> 21	0.3	0.4
Even		
2	10.0	10
4	2.5	3.8
6	1.0	1.5
8	0.8	0.5
10	0.8	0.5
12	0.4	0.5
>12	0.3	0.5
Total	20.0 %	12 %

### 3.5.10.3 Control and Measurement

Measurements may be taken at any time by **APTRANSCO** at the customer's connection point. Measurements have to be taken in accordance with methodologies of IEC 61000-4-7 or IEEE STD 519-1992 and have to be for at least 24 hours long at 10 minute measurement intervals.

### 3.5.10.4 Enforcement of Limits

The customer load harmonic limits will be implemented in stages as follows:

#### Preliminary Stage

Limits not in effect

#### Transition Stage

**APTRANSCO** will monitor current harmonic distortions at all delivery points, but no sanctions will apply for exceeding the limits

#### Final Stage



The limits in Section 3.4.10.2 will apply

Limits of Current Harmonics in LT System will be included in future versions of CTI.

### 3.5.11 Voltage Flicker Generated by Users

#### 3.5.11.1 General Description

Some customer loads draw intermittent current (e.g. arc furnace) or create a steep increase in current (e.g. motor start). If this happens frequently and if the magnitude of current is significant, the resulting voltage fluctuation will be sufficient to cause flicker. As an obligation to other customers, the flicker produced by customers has to be restricted.

#### 3.5.11.2 Indicator

Flicker generated by customers is indicated by the index Pst as defined in IEC Standard 61000-3-7 and measured with a flicker meter that meets the specification of IEC Std 868 or IEC Std 61000-4-15

#### 3.5.11.3 Limits

Tolerance for customer-generated flicker varies with the relative strength (short circuit ratio) of the load and voltage level. Limits are given in the following table.

**Limits of flicker produced by Users**

Short Circuit Ratio $S_L/S_{CC}$	Voltage	Pst
$S_L/S_{CC} \leq 0.04$	HT	0.37
	EHT	0.58

$S_L/S_{CC} > 0.04$	HT	0.8
	EHT	1.0

#### 3.5.11.4 Control and Measurement

Flicker is measured at the point of connection using an approved flicker meter and in accordance with IEC Std. Measurement must be taken for at least 24 hours at 10 minute measurement intervals. Flicker readings with the load off must be taken for at least 5 hours as a reference.

#### 3.5.11.5 Enforcement of Limits

Flicker limits and control and measurement procedure will be in effect only in the Final Stage

### 3.5.12 Power Factor

#### 3.5.12.1 General description

It is desirable that loads on the system have power factors at or close to unity as that represents the most efficient use of the system capability and the least loss of energy. It also eliminates many transient stability problems. Any load with a power factor lower than 90% is imposing an unfair burden on the transmission system and other Users. Power Companies therefore place restrictions on the power factors of customer loads.

### 3.5.12.2 *Limit*

The minimum power factor allowed is 90%.

### 3.5.12.2 *Control and Measurement*

Power factor measurements are made continuously in conjunction with the voltage measurements. Loads with inherent low power factors should automatically include capacitors to correct the problem.

### 3.5.12.3 *Penalty*

A user with power factor worse than 90% may be refused connection to the transmission grid until the problem is rectified. Alternatively, a penalty may be assessed.

### 3.5.12.4 *Enforcement of Limits*

The limit for power factor shall be effective immediately.

3.5.12.5 **Reactive Power Requirements:** In general the Distribution Companies shall not depend on APTRANSCO and APTRANSCO shall not depend on ISTS for reactive support. DISCOMS shall provide reactive compensation for their systems and APTRANSCO shall provide reactive compensation for the intra state Transmission system. The DISCOMS shall ensure that consumers having inductive load install capacitors. The DISCOMS shall also install capacitors at various locations of the Distribution System so that at the interface with APTRANSCO the power factor is not less than 90%.

## 3.6 **Operational Numbering and Nomenclature Standards**

### 3.6.1 ***Introduction***

Numbering and nomenclature of plant and apparatus at connection sites specifies responsibilities and procedures for determining and notifying APTRANSCO and Users of the other's plant and apparatus at connection sites. Nomenclature shall include the selections of sub station names.

The numbering and nomenclature of plant and apparatus shall be included in the ownership diagram prepared for each connection site.

### 3.6.2 ***Objective***

The objective of having numbering and nomenclature standards for plant and apparatus at connection sites is to reduce errors in identification of plant and apparatus by ensuring that every item of plant and / or apparatus has a unique identifying number and nomenclature agreed to and notified between APTRANSCO and Users; thus improving efficiency of operation and safety.

### 3.6.3 **Procedure for numbering and nomenclature of plant and apparatus at connection sites.**

#### 3.6.3.1 *Plant and apparatus of new connection sites*

When APTRANSCO or a User intends to install an apparatus at a new connection site, the proposed numbering and nomenclature shall be notified as part of the production of the ownership diagram or operation diagram in accordance with the provisions of the connection conditions. The principles to apply will be those set out in this Section.

#### 3.6.3.2 *Existing connection sites*

a) When APTRANSCO or a User intends to install plant and / or apparatus at an existing

connection site the proposed numbering and / or nomenclature to be adopted shall be notified to the other.

- b) The notification shall be in writing and will consist of a revised ownership diagram incorporating the proposed plant and numbering and nomenclature.
- c) The notification shall be made at least six months prior to the proposed installation or such shorter period as APTRANSCO or the User may agree.
- d) The Recipient of the notification shall respond in writing within one month confirming receipt and whether the proposed numbering and/or nomenclature is acceptable. If unacceptable the response shall state what would be acceptable.
- e) In the event that agreement cannot be reached between APTRANSCO and the User, APTRANSCO acting reasonably shall have the right to determine the numbering and nomenclature to be applied.

### 3.6.3.3 *Changes to Existing plant and apparatus.*

Where APTRANSCO or a user needs to change the existing numbering or nomenclature of any of its plant and / or apparatus at a connection site, the provisions of 3.5.3.2 shall apply with amendments necessary to reflect that only a change is being made.

**Clear Labelling:** APTRANSCO and each user shall be responsible for the provision, execution and maintenance of clear and unambiguous signs/labels showing the numbering and nomenclature of its plant or apparatus of connection sites

## 3.7 **Protection Requirements & Co Ordination**

### 3.7.1 *General Principles*

No item of electrical equipment shall be allowed to remain connected to the Transmission System unless it is covered by appropriate protection aimed at reliability, selectivity, speed, discrimination and sensitivity. Guidelines mentioned in protection manuals of CBI & P shall be kept in view.

Protection standards are treated as interface issues because of the possible severe cross-boundary repercussions of faults that occur in the system of any entity. Minimum protection requirements are prescribed in the Section because inadequate protection or mal-operation of protection system of one entity may result in far reaching consequences, disturbances and even damages in the systems of other entities.

All Users shall co-operate to ensure correct and appropriate settings of protection to achieve effective, discriminatory removal of faulted equipment within the target clearance times specified in this Section.

The protection systems to be installed (or kept in service) at various Generating Stations and sub-stations shall not be inferior to the systems existing before the effective date under the erstwhile Andhra Pradesh State Electricity Board. The Corporations shall update the protection system as technology advances worldwide. The protection standards existing in AP State just before restructuring are given in 3.6.3.1 to 3.6.3.4. the features and functions of the various relays should have minimum protective capability obtaining before re-structuring.

Protection settings shall not be altered without consulting and informing all affected Users. No protection should be by-passed or disconnected without the agreement of the affected User. When protection is bypassed and/or disconnected by agreement, then the cause must be rectified and the protection

restored to normal condition as quickly as possible. If agreement has not been reached the electrical equipment shall be removed from service forthwith. Even when protection is temporarily bypassed by agreement, a standby protection or back-up protection system shall be operational during the period.

The **APTRANSCO** shall be responsible for arranging periodical meetings among all Users to discuss coordination of protection. **APTRANSCO** shall investigate any maloperation, non-operation or delayed operation of protection or other unsatisfactory protection performances. Users shall take prompt action to correct any protection malfunction or issue as discussed and agreed to in these periodical meetings. **APTRANSCO** shall determine the relay settings of all Transmission lines and communicate to Generating stations and **DISCOMs**. **APTRANSCO** shall determine relay settings at all EHT Sub-Stations upto the LV side of the Power Transformers. Relay settings at Generating Stations shall be determined by the generating station authority. The settings of some relays including relays of EHT Feeders emanating from generating station switchyard which require coordination with **APTRANSCO** shall be determined in consultation with **APTRANSCO**. The data required by **APTRANSCO** in respect of equipment in Generating Station for calculating fault level shall be promptly furnished by the Generating Station in the format prescribed by **APTRANSCO**. **DISCOMs** shall finalise the settings of all the protections for the 33 kV and 11 kV feeders emanating from **APTRANSCO**'s Sub-Stations for satisfactory function in consultation with **APTRANSCO**. The final authority for protection coordination and determination of relay settings is SREB. Therefore the protection schedules provided and relay settings must be approved by SREB.

### 3.7.2 *Fault Clearance Times*

The maximum fault clearance times for faults based on stability consideration on any User's system directly connected to the Transmission System, or any faults on the Transmission System itself, are as follows.

**Target Clearance Times**

<b>Voltage Class</b>	<b>Total Relay Operation Time + Breaker Opening Time</b>
400 Kv	100 msec
220 kV	160 msec
132 kV	160 msec

**The above times shall apply after carrier inter trip and auto reclosure features are commissioned in the APTRANSCO System.**

Slower fault clearance times for faults on a Users system may be agreed to if, in the opinion of **APTRANSCO**, the system conditions will allow. **APTRANSCO** shall specify the required opening times of circuit breakers at various locations owned by **Generators** and **DISCOMs**.

### 3.7.3 *Protection Requirements*

#### 3.7.3.1 *Generator Requirements*

All Generating Units and associated electrical equipment of the Generating Units connected to the Transmission System shall be protected by adequate protection so that the Transmission System does not suffer due to any disturbance originating from any Generating Unit. The protection schemes shall be in accordance with the CBIP guide lines which are indicated below:

The following are the minimum protection requirements of Alternators and Generator Transformers at Generating Stations: -

- (i) Generator Differential
- (ii) Overall Differential
- (iii) Minimum Impedance (alternatively over current/under voltage)
- (iv) Negative Sequence
- (v) Stator Overload
- (vi) 95% Stator Earth Fault
- (vii) 100% Stator Earth Fault
- (viii) Loss of Excitation
- (ix) Pole Slip
- (x) Low Forward Power/Reverse Power (double protection for large alternators).
- (xi) Minimum Frequency
- (xii) Over Voltage or Over Current (protection against inter-turn faults)
- (xiii) Over-fluxing (voltage/Hz)
- (xiv) Over Voltage
- (xv) Protection against accidental Energisation of Dead Machine
- (xvi) PT Fuse Failure
- (xvii) Rotor Earth Fault

#### Generator Transformers

- (i) Overall Differential
- (ii) Over Current
- (iii) Earth Fault
- (iv) Restricted Earth Fault
- (v) HV winding-cum-overhang differential
- (vi) Buchholtz Protection
- (vii) Local Breaker backup protection

#### Unit Auxiliary Transformer

- (i) Transformer Differential
- (ii) Over Current
- (iii) Residual Over Current
- (iv) Restricted Earth Fault
- (v) Buchholtz Relay

(Note: Exemption may be given to small generating units for some of the protections.)

In this sub-section only those protections which have direct impact on the Grid are prescribed. Other protections of the Alternator and Transformers and the various protections for the Turbine, Boiler and Auxiliary Machines are considered the internal issues of the Generators and hence not dealt here.

#### *3.7.3.2 Transmission Requirements*

**General:** Every EHT line taking off from a Power Station or a Sub-Station shall have distance protection and back up protection as mentioned below. The **APTRANSCO** shall notify Users of any changes in its policy on protection from time to time. All 400 kV lines and 220 kV lines

owned by **APTRANSCO** shall have two fast operating distance protection schemes preferably with two different operating principles the voltage of one relay being fed from Bus P.T. and the voltage of the other relay from line CVT, the currents of the two relays being fed from different CT cores. There shall be facility to change over voltage supply to relays from Bus P.T to C.V.T. and vice versa. Additional back up protection may be provided by **APTRANSCO** at its discretion.

**400 kV Lines:** Three zone static fast acting distance protection with permissive inter trip for accelerating tripping at remote end in case of zone-2 fault as Main 1 protection. Main 2 protection shall be similar fast acting protection using direction comparison or phase comparison carrier relaying scheme. Main 1 and Main 2 are preferably to have different operating principles.

In addition to the above single pole tripping and single shot single pole auto reclosing after an adjustable dead time shall be provided.

Main 1 and Main 2 shall have DC supplies from different batteries.

**220 kV lines:** Main 1 shall be Three zone static distance protection . Main-2 protection shall be a distance protection scheme preferably having a different operating principle.

Necessary indications, alarms and controls shall be provided for P.T. supply failure and for ensuring change over from Bus No.1 PT to Bus No.2 PT and vice versa when Bus Transfer is made.

Presently carrier inter trip has not been installed by **APTRANSCO**. This feature shall be provided in due course for accelerating tripping at the remote end in case of faults covered by Zone 2 from one end.

**132 kV Lines:** Three zone static or electromagnetic distance protection as main protection. Carrier inter-trip feature shall be provided as soon as possible. The back up shall be directional IDMT over current relays and one directional IDMT earth fault relay.

For short transmission lines alternative protection schemes may be adopted.

The tripping and relay indications in respect of Feeders supplied from the switchyard of a generating station shall be promptly informed by the operator at the Generating Station to the operating engineer of **APTRANSCO** and to **SLDC**.

The following shall be taken as approved protection norms for Transmission and Distribution lines.

-  
**NORMS OF PROTECTION FOLLOWED DURING ERSTWHILE APSEB REGIME.**  
**FOR TRANSMISSION & DISTRIBUTION LINES: -**  
-

S.No	Voltage	Protection Scheme
1.	220 K V Line	Main I : Non switched distance scheme (Fed from Bus PTs) Main II: Switched distance scheme (Fed from line CVTs) With a changeover facility from bus PT to line CVT and vice-versa.
2	132 K V Line	<b>Main Protection:-</b> Switched distance scheme (fed from bus PT) <b>Backup Protection:-</b> 3 Nos directional IDMT O/C Relays and 1 No directional IDMT E/L relay.

3	33 K V Lines	Non-directional IDMT 3 O/C and 1 E/L relays.
4	11 K V Lines	Non-directional IDMT 2 O/C and 1 E/L relay.

### **Notes:**

- (i) On some of the old 220 kV lines one distance scheme with backup directional IDMT 3 O/L & 1 E/L relays were provided.
- (ii) On some of the 132 kV grid lines, only distance scheme is available.
- (iii) Very few 66 kV lines are in service (which are also being phased out) with distance OC/EL relays.

3.7.3.2.1 Earthing: The transmission system design and the selection of vector group of EHT Transformers shall be such that the Earth Fault Factor is below 1.4

### 3.7.3.3 *Distribution Line Requirements*

All 33 kV and 11 kV lines shall be provided with a minimum of over current and earth fault protection with or without directional features as given below.

#### Plain Radial Feeders:

Three Non-directional time-lag overcurrent relays one non-directional IDMT Earth Fault Relay with suitable settings to obtain discrimination between adjacent relay stations.

#### Parallel Feeders/Ring Feeders:

Directional time-lag overcurrent and earth fault relays.

#### Long Feeders/Transformer Feeders:

For long feeders or transformer feeders, the relays should incorporate a high set instantaneous element within five years from the effective date..

The relay settings of the Distribution systems shall be determined by the DISCOMS in agreement with **APTRANSCO**.

### 3.7.3.4 *Transformer Requirements*

**Generating Station / Transmission System:** All windings of autotransformers and power transformers of EHT class shall be protected by differential relays. Overfluxing relays shall be provided for HV and LV of EHT transformers. In addition there shall be back up time lag over current and earth fault protection. For parallel operation such back up protection shall have a directional feature. For protection against heavy short circuits, the over current relays should incorporate a high set instantaneous element. In addition to electrical protection, gas operated relays, winding temperature protection and oil temperature protection shall be provided.

Distribution System: Up to (but Excluding )15 MVA, Non-directional IDMT overcurrent relays (3 nos) and earth fault relay (1 No) both on HV and LV side Instantaneous REF shall be provided within 5 years from the effective date.

For smaller transformers of 66 kV/33kV/11kV class on the Distribution System, differential protection shall be provided for 15 MVA and above along with back up time lag over current and earth fault protection (with directional feature for parallel operations).

All Power Transformers, 1.6 MVA and above, shall be provided with Buchholtz relay, winding

temp and Oil temp. protection in addition to the above mentioned relays. For 1.6 MVA and 3.0 MVA Transformers circuit breakers do not exist on HV side hence the protections serve to isolate load and initiate alarms.

The following shall be approved norms of protection for transformers of different voltage classes and capacity ratings:-

### NORMS OF PROTECTION FOR EHV CLASS POWER TRANSFORMERS

(existing in erstwhile APSEB Regime.)

Voltage ratio & capacity	H V Side	L V Side	Common relays
i) 132/33/11 K V upto 8 M V A	3 O/L relays + 1 E/L relay	2 O/L relays + 1 E/L relay	Bucholz, OLTC Bucholz, OT, WT
ii) 132/33/11 K V above 8 MVA and below 31.5 MVA.	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 E/L relay	Differential, , Bucholz, OLTC Bucholz, OT, WT.
iii) 132/33 K V 31.5. MVA and above	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 E/L relay	Differential, Overflux, Bucholz, OLTC Bucholz, PRV, OT, WT.
iv) 220/33/ KV 31.5 MVA & 50 MVA 220/132 KV 100 MVA	3 O/L relays + 1 dir. E/L relay	3 O/L relays + 1 dir.E/L relay	Differential, Overflux, Bucholz, OLTC Bucholz ,PRV, OT, WT
v) 400/220 KV 315 MVA	3 directional O/L relays (with dir. Highset) + 1 directional E/L relay. Restricted E/F relay	3 directional O/L relays (with dir. highset) + 1 directional E/L relay. Restricted E/F relay	Differential, Overflux, Bucholz, OLTC Bucholz PRV, OT WT and overload (alarm) relay.

#### 3.7.3.5 Substation Bus Bar Protection

Adequate bus zone protection for substation bus bars in all 400 kV and 220 kV class substations shall be provided.

LBB: At all 400 kV & 220 kV substations Local Breaker Back up protection shall be provided.

#### 3.7.3.6 Fire Protection

Fire protection systems and regulations shall be in accordance with relevant Indian Standard Specification and provisions in IE Rules & Tariff Advisory Committee (TAC). Where appropriate Indian rules do not exist or are not applicable, NFPA Fire Protection Manual or IEC standards (or better standards) shall apply

#### 3.7.3.7 Data Requirements

a) Full description including settings for all relays and protection systems installed on the



Generating Unit, Generating Unit Transformer, Auxiliary Transformer and electrical motors of major equipment listed.

- b) Full description including settings for all relays installed on all outgoing feeders from power station switchyards, tie circuit breakers, incoming circuit breakers.
- c) Full description of inter-tripping of circuit breakers at the point or points of connection with the **APTRANSCO** system.
- d) Most probable fault clearance times for electrical faults on the User's system.
- e) Relay protection installed for all transformers and feeders along with their settings and level of co-ordination with other Users.
- f) See Section 2 (Planning Code) Appendix C for a summary of the protection data requirements.
- g) Data required for determination of short-circuit current at each point of connection and rupturing capacities of breakers shall be exchanged between utilities.
- h) Data as prescribed in the Annexures to Planning Code in various contexts.

### 3.8 Earthing

Where a point in EHT system of APTRANSCO is earthed the Earth Fault Factor shall be below 1.4

(Like most stipulations in the Connection Code the clauses in the following paras must be taken into account by the Generators while placing orders of equipment on Manufacturers)

### 3.9 Design Parameters of New Generating Units.

- (i) **New Units:** For new plant para 3.2.5 (a), this para (3.9) and other paras of this Code apply. For plant existing as on the Transfer date the actual specifications hold for the life period of the equipment. However if certain parts can be replaced at reasonable investment then those parts shall be replaced under a Renovation, Rehabilitation and Modernization Programme to ensure better performance to conform to the requirements of CTI and IEGC. For example the Generators shall replace the Turbine Speed Governors and AVR systems of the alternators, and instal Power System Stabilisers if technically possible in order to meet the operating standards of the CTI and IEGC.  
In addition APTRANSCO may require Generators to comply with other specifications in a bilateral agreement before the Connection Application is accepted in order to ensure the required performance of the transmission system and the total system.
- (ii) The Generating Units shall be capable of supplying rated active power output between 0.85 power factor lagging and 0.95 power factor leading.
- (iii) The Short Circuit Ratio of Generating Units shall be not less than 0.5.
- (iv) A Generating Unit shall be capable of supplying rated active power output within the system frequency range 49.5 to 50.5 Hz.
- (v) **Decrease of output with decrease of frequency:** Any decrease of output in the frequency range 49.5 to 47 Hz should not be more than pro rata with frequency. The Generating Units must be capable of operation in 47.5 to 52 Hz range for a short duration without any deleterious effects and without reduction of life.
- (vi) **Effect of Voltage Fluctuations:** The MW output of a Generating Unit should not be affected by voltage changes in the permissible range. The Reactive Power Output under steady state conditions should be fully available as per capability curves within a voltage range of  $\pm 5\%$  of nominal value.

- (vii) **Governors:** All new Generating units must have automatic Governors with a droop of 3 to 6% and automatic voltage regulators. Power System Stabilizers shall be installed under a bilateral agreement with APTRANSCO. All new units shall have provision for incorporating power system stabilizers, if not provided at the time of initial commissioning.
- (viii) **Overloads:** All new Generating units must be capable of instantaneously increasing the output (by auto governing action) by 5% for a minimum of 5 minutes (upto 105% MCR) when the system frequency falls.
- (ix) The HV winding of the Generator Transformer must be star connected with the star point suitable for earthing. The earthing of HV star point and the configuration of LV winding shall be such as to enable APTRANSCO to achieve the requirement that the Earth Fault Factor in Transmission System shall be 1.4 or less as stipulated in 3.7.3.2.1.
- (x) CCGT Modules meant for Central Despatch must have Fast-Start capability so that SLDC may use them for Operating Reserve.
- (xi) Thermal Units must be capable of continuous stable operation at any load between 60% MCR and 100% MCR without oil support and between 45% and 60% MCR with oil support.
- (xii) Hydel Units must be capable of continuous stable operation at any load between 40% MCR and 100% MCR.

**3.10 Operational Metering:**

Whenever APTRANSCO implements EMS and SCADA Projects, the user shall provide measurement outputs of Voltage, Current, Frequency and Active and Reactive Power, plant status indications and alarms to APTRANSCO SCADA outstation interface equipment.

**General Format of Site Responsibility Schedule**

Name of Power Station/Sub-station: ..... Site Owner: .....  
 ..... Tel. Number: .....  
 ..... Fax Number: .....  
 .....

Item of Plant/Apparatus 1	Plant Owner 2	Safety Responsibility 3	Control Responsibility 4	Operation Responsibility 5	Maintenance Responsibility 6	Remarks 7
..... kV Switchyard						
All equipment including busbars						
Feeders						

Generating Units						

**Note:** Three items shall be added to this schedule: -

- (i) Safety Rules pertaining to safety of each piece of equipment.
- (ii) Safety Rules pertaining to system operation
- (iii) Safety Rules for safety of operating personnel.

## APPENDIX B

### Specifications of Under Frequency Relays

- (i) Frequency Settings : 46 to 49.0 Hz  
in steps of 0.05 Hz
- (ii) Measurement Period : Within minimum selectable settings  
Settings : range of 4 to 8 cycles.
- (iii) Operating Time : 100 to 250 ms
- (iv) Operating Voltage : 50 to 100% of nominal voltage with  
provision for selection.
- (v) Stages : Two stages.