TAMILNADU ELECTRICAL INSTALLATION ENGINEERS' ASSOCIATION 'A' GRADE

NEWSLETTER

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TAMILNADU ELECTRICAL INSTALLATION ENGINEERS' ASSOCIATION 'A' GRADE (Regn. No. 211/1992)
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GRAND FAMILY GET-TOGETHER - 2023
TECHNICAL SEMINAR
on 19th, 20th, 21st May 2023, Fern Hill Sterling Resorts, Ooty

Inauguration - Lighting of Traditional Lamp

Technical Seminar Inauguration - Lighting of Traditional Lamp

Members Gatherings

TNEIEA honouring the team of
M/s. KEC International Ltd., Chennai

TNEIEA honouring the team of
M/s. Legrend, Chennai

TNEIEA honouring the team of
M/s. Infinite Electrotech Pvt. Ltd.,
Chennai

TNEIEA honouring the team of
M/s. Sri Bhoomidurga Marketing Pvt. Ltd.,
Chennai

TNEIEA honouring **Mr. S. Gopalakrishnan,**
Ex-Secretary, Erode

TNEIEA honouring **Mr. N.N. Bharanidharan,**
Joint Secretary, Erode

Winners of Lucky Draw for Members

Technical Seminar on 20th May 2023 at Ooty

Mr. R. Muruganantham
M/s. Airtex Electrical Services,
Coimbatore

Mr. J. Prakash
M/s. Shree Abirami Engineering Pvt. Ltd.,
Chennai

Mr. V. Sivakumar
M/s. Shree Dhivya Enterprises,
Kanchipuram

Mr. V. Johnson
M/s. Rathna Enterprises,
Chennai

Mr. T.K. Kumar
M/s. Winpower Engineering,
Chennai

End Session

EVENTS PROGRAM
Grand Family Get-together - 2023

EDITORIAL

Dear Members, Fellow Professionals and Friends,

Greetings to all!

June is the month, where the colleges are busy with admissions, the concern now is that, every student wants to choose Computer Science, Artificial Intelligence, Cyber Security or Data Analytics. As a matter of fact, there are no demand for other main core Engineering branches like Electrical, Mechanical, Civil & Electronics. If the same continues for few years, we will have a huge vacuum in finding people in core Engineering Industries.

We have World Environment Day and National Environment Week in the month of June, signifying the need and urgency of Global and National actions and initiatives to be speeded up. Carbon reduction, Net'0' emission levels, Global Warming to be arrested and Environmental Safety has to be taken up seriously. This summer we had temperatures rising upto 50 degrees and heat waves too. High time we give priority to the environment, educate public and the youngsters to plant more trees and the use of public transport.

We thank all those members who have helped us by participating in the advertisement appearing for the issue April 2023 – 3SI Eco Power LLP, Ashlok Safe Earthing Electrodes Ltd., E Power Engineering, Galaxy Earthing Electrodes (P) Ltd., Gravin Earthing & Lightning Protection System (P) Ltd., Global EPC India Private Limited, MV Power Consultants & Engineers (P) Ltd., Pentagon Switchgear (P) Ltd., Power Cable Corporation, RBB Electricals, Sakthi Transformers, Sri Bhoomidurga Marketing (P) Ltd., Supreme Power Equipment (P) Ltd.

Editor

OBITUARY

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Advisor to Newsletter TNEIEA

16-08-1943 - 16-05-2023

Worked at M/s. GEC & M/s. Bharat Bijlee Ltd., and was a visiting faculty for ITM Chennai, Ramakrishna College of Engineering, Trichy & Christ College, Bangalore.

Mr. S. Mahadevan was an advisor to Newsletter, TNEIEA. He has contributed many Technical & Professional articles to our Newsletter for over 2 decades.

We are honoured to have,
had him as part of our team,
we are thankful for his
hard work and dedication

- President, Secretary & Treasurer and All Committee Members

Tamilnadu Electrical Installation Engineers' Association 'A' Grade

NEWSLETTER

CONTENTS

KNOW THY POWER NETWORK - 171

(Addressing the challenges, threats and risks brought by over voltage waves in a U.G. cable network)

I Introduction

When you ask any electricity consumer about his/her preference for the mode of delivery of electricity to their homes / premises - OH line or U.G. cable system? Invariably you can find that quoting safety aspects, majority people, will prefer UG cable system over OH line network. Is this choice correct? No, it is an incorrect or wrong preference.

Why it is so? To find answer, we need to weigh carefully the

- Personnel Safety
- Equipment Safety
- Supply Failure
- Faults Rectification
- Cast and other aspects

Due to lack of awareness, normally we fail to perform these steps.

So to understand the issues related to U.G. cable system, we need to look at their operational experience, flexibility of installation and

- Unusual events and uncommon risks that are associated with their operation. Among the major risks faced in U.G. cable system, though rarely are,
    - Dig-in faults that bring unusual power frequency over voltages in its wings.
    - Ferro resonance phenomena that generates destructive P.F. over voltages

These two events routinely bring costly damages and endanger human / equipment lives. Yet it finds limited / no response from the suppliers and consumers as well.

The U.G. cable network in Chennai city is no exception to such problematic, disturbing events. It happens regularly in the network without getting the required focus / attention (wide publicity).However, at times, the severity of the faults and the keenness exhibited by the "affected consumers" bring to the fore the occurrences of such harmful, high profile events.

Two known high profile events that had happened in Chennai city U.G. cable network are presented here. It provides a clear demonstration by throwing adequate light on their destructive and undetectable nature. It also explains how these events escape detection from the penetrative eyes of the protective devices concerned.

To provide a clear perspective, this analysis is made in a "question – answer" form.

II Questions

(1) Over voltage kya? (What do you mean by over voltages in a power network?)

(2) How do they occur? How the equipment got adversely impacted by it?

(3) How to get a grip on it? Or what are the protective measures for it? Or how to place a lid on them?

(4) What are the measures available to meet the "day-to-day voltage variations" experienced i.e. 170V – 270V range excursion in the normal incoming LT voltage band supplied at our premises? i.e How to iron out these voltage variations?

(5) What is the protective measures available for LT lighting circuits?

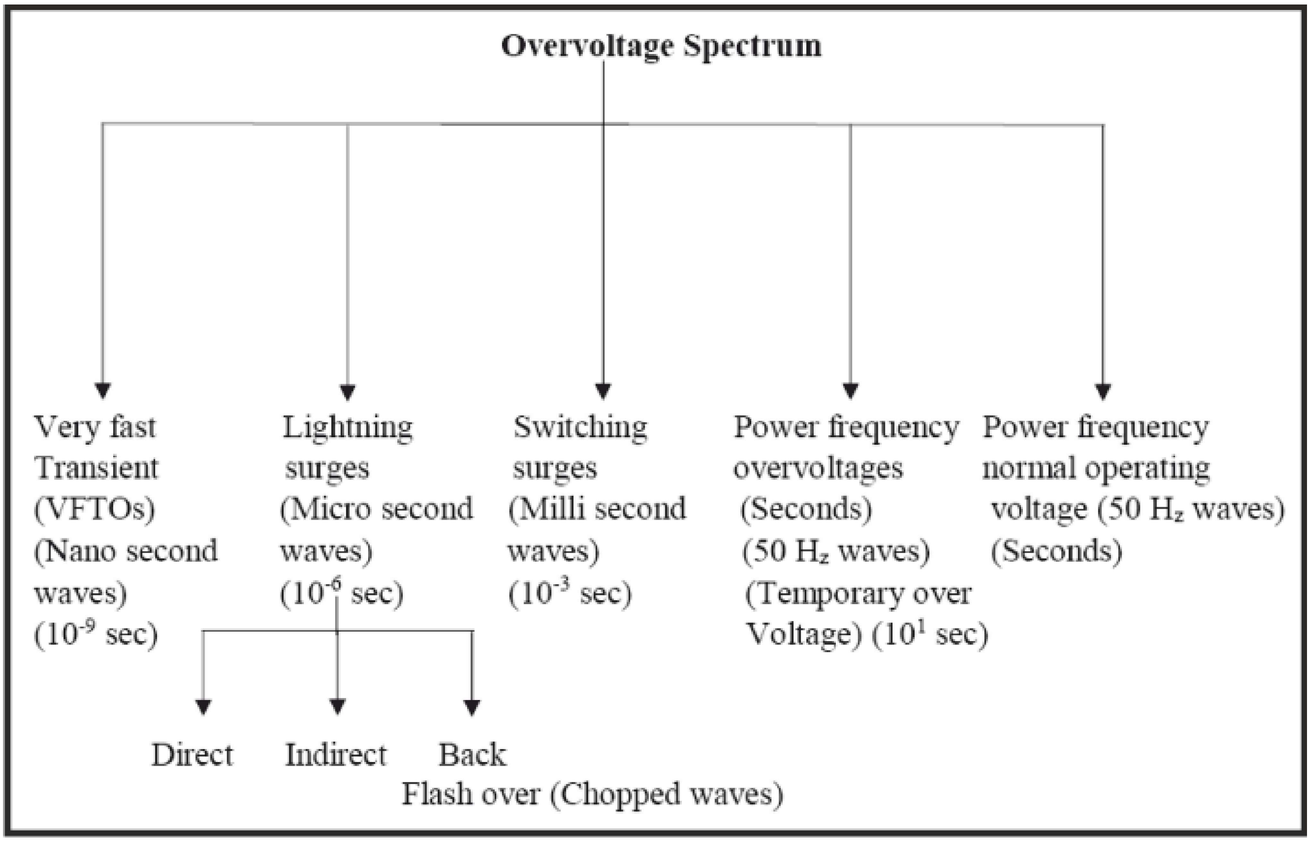
(6) What are the over voltage issues brought in by "Dig in faults and Ferro resonance phenomenon"? What are the specialty about them? Why are these faults treated as undetectable, uncommon and

unusual faults? Is it due to their inherent nature of growth- slow and difficult to detect? And finally how to "face off" these invading waves.

III Answers

Q 1. Over voltage kya?

It is difficult to explain / define the over voltages experienced in our power network in simple terms because of its complicated nature. i.e the presence / involvement of several kinds / types of voltage wave forms and frequencies. At best, it can be stated as the voltage impressed across the equipment that exceeds the withstand capability of its insulation for that "band or type".



Q 2. (a) How do they occur?

S. No	**Description**	**Causes / Origin**
1.	VFTOs	I. Internal 1. System generated waves 2. GIS Breaker on-off switching operations II. External 1. Direct lightning phenomena
2.	Lightning Surges (Direct, Indirect and Back flash over)	Natural phenomena (An external phenomenon)
3.	Switching Surges	(Internal / System generated waves) Switching operation of circuit breakers in a power system (Energization of Buses O.H. lines, U.G. cables, Capacitors, Transformers, Generators, Reactors)

4.	Temporary Over voltages	System Generated waves ➢ System Faults, Regulation (Sudden load shedding) ➢ Over speed of generators ➢ Over fluxing of transformers ➢ Dig-in faults in U.G. cable system (High impedance faults) ➢ Ferro-resonance caused by the resonance of non-linear elements in the circuit ➢ Ferranti effect-energization of long transmission lines and shunt capacitors banks ➢ Trapped charges on transmission lines ➢ Self-excitation of transformers and Induction motors by shunt capacitor banks ➢ Use of salient pole machines without damper windings ➢ Accidental contacts with H.V. circuits ➢ Arcing faults ➢ Low clearances between L.V. and H.V. circuits

Q 2. (b) How do these over voltages adversely impact the Equipment Insulation?

Sufferings of Equipment Insulation under power frequency over voltage conditions cannot be simply described. It has to be witnessed / experienced. The equipment insulation is literally crushed under the jaws of the voltage waves. Higher the voltage, higher will be its suffering. Actually the insulation is squeezed and the leakage current (dielectric current) emanates from its insulation layers.

When it faces high voltage surges, it faces a sudden sharp slap that may even puncture its insulation layers. So does the lightning and switching surges. Amongst them,the switching surges are more severe because ofits long lasting higher energy content and applied time. Frequent exposures to such higher voltages, may endanger and weaken the insulation and create a few weak spots / hot spots that may lead to its destructive failure in course of time. Presence of moisture ingress acts as a catalyst under such circumstances.

Q 3. How to get a grip on the over voltages that present / appear in a power network?

(Preventive / Protective measures against the over voltage waves that find a place in over voltage spectrum)

S. No	Description	Protective Measure
1.	VFTOs	Equipment has to be designed and tested for its safe withstand level. To a certain extent, Metal oxide surge arresters (MOSA) can offer good protection. Then stray and black capacitance effects should be limited
2.	Lightning Strokes (Direct)	No effective protection can be provided; equipment has to be designed adequately, so that it can withstand such waves; effective diversion of surge energy can be provided by Masts, Ground wires, Spikes, Spark gaps and Good earthing spikes.
3.	Indirect lightning strikes + Switching Surges	1. Metal oxide surge arresters with reasonably low Protective levels. 2. Effective Earthing
4.	Power frequency over voltage (Temporary Voltage)	Complete protection cannot be arranged. However effective earthing and well-designed equipment that will withstand the permissible

		Maximum Continuous Operating Voltage (MCOV), which is in the order of (second to several seconds), can offer a reasonable relief or protection. **Maximum Magnitude** - $\sqrt{2}$ to 2 times the L-L voltage depending upon the system earthing (Earthing factor)
5. (a)	Service frequency (50 Hz) operating voltage level.	Max. permissible level for Very short period] 110 % of nominal voltage (i.e. 245 V x 110% in the case of L.T. equipment) Well-designed Servo Stabilizers and Effective Earthing can offer good protection
5. (b)	L.T. Lighting Circuits	Lighting Energy Savers

Q 4 & 5. What are the protective measures suggested for the voltage excursions (From 170V to 270V) currently experienced in all the L.T. services (Domestic and Commercial services and High Rise Apartments)? Also for the intruding High Voltage Surges?

As a reasonable protective measure, good earthing of the premises and the use of Servo stabilizers of adequate capacity and protective voltage level are suggested. As regards surge protection, effective earthing, separate earth pits for surges. Lightning Masts, Ground wires and MOSA with low protective level are recommended. The voltage regulation in a servo stabilizer is 1 percent (220 ± 2) volts whereas the same regulation is around 9% or 220 ± 20 volts in Automatic Voltage Stabilizers (normally provides for Air conditioners, Refrigerators and TVs). Further in Automatic stabilizers the bucking of voltage starts at 270 volts (not at the required level of 250 volts). So it is preferable to select Servo voltage stabilizers to get adequate protection. In addition, it is preferable to install data loggers in the circuit. It enables us to get the useful data to analyze the problems experienced. The suggested over voltage protective measures are a “Must” for all the L.T. services especially those located in the Rural Networks where single phasing operation is carried out for a few hours daily. (i.e High voltage level prevails for a few hours daily – L-L voltage 460V – 500V). Regarding the low voltage inputs in the L.T. lighting circuits, provision of lighting energy saver is the best option.

Undertaking tap charging operations in the feeding transformer may not be a good option as it has the potential to land us in problematic situations.

Q 6. High profile events - In brief

Problem outline

Case I – Abnormal voltages were observed in a 3 phase L.T. domestic service in Nungambakkam distribution of Chennai electricity system in the late evening on “16.10.87”. The service was fed by 3 ½ x 120 Sq.mm. PVC armoured L.T. cable. (Refer Fig 1)

(i) Observations made at site– Nature of faults faced

The first observation is that the Power Frequency over voltages were off the blocks and played a major role.

Among the other notable events were,

- Violent flickering of lights in the affected S.C.
- Subsequently very high L-G voltages were noticed.
- It led to severe damages to the Heater, Television set in the S.C. in point
- Flickering of lamps and blowing of protective fuses occurred in all the service connections fed by the feeding L.T. cable concerned.
- Fuses provided in the pillar box ahead of the one that was feeding the service connection in point had blown.

- The feeding cable caught fire in the next few seconds leading to total black out in that area.

(ii) Pre-failure Events

The cable in point suffered damages due to "dig-in fault" – caused earlier by Chennai corporation electricity department staff.

There were rains in that locality on 15th and 16th Oct. It led to moisture ingress in the affected cable; it acted as a catalyst and brought a high impedance, intermittent fault accompanied with arcing and over voltages. All these had triggered / sparked off higher P.F. over voltages in the circuit. (Very high L-G voltages upto the level of L-L voltage)

(iii) General causes for over voltage phenomenon in a L.T. U.G. Cable network

Under many conditions, the voltages present in a L.T. three phase, four wire underground cable network may exceed the permissible service frequency voltage level. Among them are:

(a) Open Neutral:

When discontinuity of the neutral conductor of the main supply (3 phase, 4 wire cable) occurs dangerous excessive voltages will be encountered at the load end due to unbalance. Under such conditions, the neutral potential floats at a voltage level determined by the relative quantum of consumers' loads.

(b) Phase to Earth Fault:

Severe overvoltages are found to occur with a single line-to-ground and double line-to-ground faults. If the faults are accompanied with arcing, the damage will be accentuated. The over voltages observed on un-faulted phase during ground faults last for relatively long intervals. Their duration depends upon the time taken by the circuit protective devices to clear the fault. These sustained over voltages are chiefly dependent on the system operating voltage, the method of grounding of the system neutral and the distribution circuit impedance. These voltages cannot be discharged by arrester type protective devices without damages to these devices and hence they cause injuries to other equipment in the vicinity. The magnitude of these abnormal voltages vary from 175 to 200 percent of normal line-to-ground voltage.

(c) Resonance:

(a) Opening of one of the phase conductors of a three phase U.G. cable may cause abnormal voltage, if the power factor of the load existing after such single phasing is less than 0.5 lagging.

(b) Sustained overvoltage can occur on the downstream, L.T. Network, when one or two phases are open in the upstream H.T. Cable, with a resonant circuit existing between the magnetizing reactance of the connected transformer and the capacitive reactance of the opened H.T. Conductors. This phenomenon is known as "Ferro-resonance".

(d) Faults in the Feeding Distribution Transformer

Excessive overvoltages can be expected on the L.V. side, when the H.V. winding of the transformer comes into contact with the L.V. winding and there is delay in the operation associated of the protective devices.

(e) Load Shedding:

When bulk loads are suddenly cut off, excessive voltages can be expected.

(f) Ferranti Effect:

Dynamic overvoltages can be expected at the receiving end of long, lightly loaded cables, due to this effect.

(g) Origin and the cause of the over voltage phenomenon under study:

As mentioned earlier, owing to third party damage, the neutral core and one of the phase cores of the secondary distributor cable had suffered mechanical cuts. The damage caused to the phase and neutral conductors gradually developed into a fault with the monsoon rains that followed the above occurrence. The penetration of moisture into the insulation of the above cores led to its gradual deterioration with consequence development of high impedance line-to-ground fault. Now the destructive journey of the over voltage waves kicks off its blocks (starts). As the deterioration of the cable insulation was a relatively slow process, the transitory fault produced by it did not generate sufficient leakage current to operate the protective fuses provided in the controlling pillar boxes. Successive transitory breakdowns extend the damage to region around the fault, with increase in the rate of moisture ingress. This small leakage current caused continuous arcing, which in turn led to the heating of the PVC insulation of the cable with consequential fire and burning of the faulty cable length. In the process, all the three phase got shorted and got cut; the neutral core was also cut. At this time, the fault current magnitude was high enough to blow out all the three circuit fuses provided in the adjacent pillar box and the fire got extinguished. Thus the wound inflicted on the cable in point and the moisture ingress in it was the main cause for the excessive voltage and the flickering of lights, observed in the affected area during the early night hours on 16.10.1987. The fault being complex in nature, it is difficult to quantity the magnitude of overvoltage that had occurred for want of data logger. As an approximation, it may be taken that the voltage oscillations generated by the arcing earth under study might have been of the order of two times the normal line-to-ground voltage in the circuit. The inadequate co-ordination between the fuse provided in the pillar adjacent to the one under study and the pillar that fed the effected S.C had amplified the problem.

(h) Possible cause for the failure of L.T. appliance in the affected three Phase Domestic Service:

Due to the line-to-ground fault in the distributor cable, the neutral attained the potential of the phase with which it got into electrical contact through the high impedance arc path. At this stage, the neutral became a source of hazard; when the supply was switched on in the affected service, line-to-line potential was impressed across the connected L.T. appliance. This resulted in very heavy current in the circuit with consequential heat generation and eventual burning of the supply loads. The fault current was within the withstand level of the protective fuses provided in that installation. As a result, it was inactive and could not come to the rescue of the L.T. appliances in distress.

Case – II – K K Nagar distribution, Chennai city distribution circle Suddenly 400V came in a L.T. SC - in place of L-G 230V, 400V was observed leading to the burning of one eliminator, wild running of fans and failure of kitchen lights. Subsequently the fuses in the feeding transformer had blown off. Reported cause- RYB cores of the feeding cable got shorted; its neutral also got burnt.

(i) Suggested Preventive Measures:

The overvoltage phenomenon now under analysis is common in L.T. underground cable three phase four wire distribution networks, where third party damages are inflicted to cable mains with attendant gradual deterioration of cable insulation, moisture ingress and high impedance arcing grounds. Though such cases cannot be totally eliminated, the severity of the problem faced can be mitigated by having effectively earthed neutral system and by the adoption of the various remedial measures. Such steps should be tailored around limiting the severity of the potential adverse impacts i.e.these waves should be adequately controlled in their tracks before they brought major damages.

(i) When other agencies undertake trenching work near power cable installations, a representative of the TANGEDCO may be deputed to witness the trenching works to ensure against injury to the Board's cable mains.

(ii) The existing multi-earthed neutral system in L.T. U.G. network should be made effective i.e. the cable armour and neutral core should be connected effectively at the neutral bus and earth bus in the transformer end and service pillar boxes. This step will reduce the severity of the arcing ground, if any occurs and also the consequent damages.

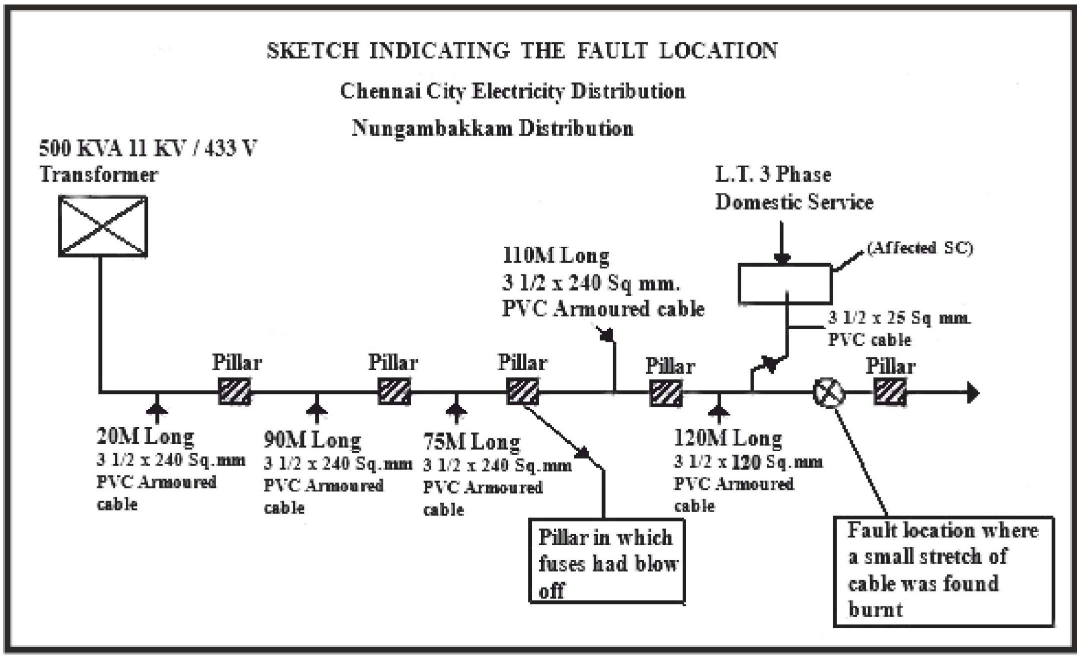
(iii) Concrete or celcrete trough coverage should be provided for L.T. cable, installations in dig-in-fault prone areas.

(iv) L.T. rewirable fuses currently in use in distribution pillar take comparatively longer time to blow out.To ensure effective protection of cables, use of modern automatic protective devices like Moulded case circuit breakers (MCCBs) with proper overvoltage relays or HRC fuses are suggested. Such modern devices are understood to be in service in other metropolitan cities in the country, Viz., Bombay and Delhi.

(v) The earth connections at the consumers' premises should strictly conform to the departmental practice i.e. there should be secure connection between the consumers' earth and supply system neutral. During periodical inspection of the consumers' installations under Rule 46 I.E. Rules, this aspect should be checked.

(vi) The consumers' may be advised to use modern residual current devices and HRC fuses in place of the outdated rewirable fuse units. These residual current devices have built-in electronic circuitry to detect potentially hazardous situations, discontinuity of neutral, inter change of phase and neutral etc. It is to be stated that as per 61 A of I.E. rules 1954, the use of earth leakage circuit breaker is mandatory for all low voltage installations with a load of 5 KW or more.

(vii) Installation of fast acting circuit breakers with overvoltage tripping feature at the consumers' premises will be an ideal solution for the over voltage problem as hand, but for the cost factor.



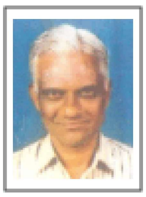
(vii) Summary and conclusions

The commonly experienced PF overvoltage phenomenon in L.T. U.G. cable network has been brought into proper prospective. For want of proper operating overvoltage protective devices, such dangerous PF over voltages cannot be contained. As we can neither prevent its origin nor negate its impacts, the equipment concerned should have to be well designed and provided with an adequate safe space. That is, it has to withstand such abnormal operating conditions within the boundaries of its withstand levels. Possible remedial measures have been outlined so as to reduce the severity of the such over voltage phenomenon in the LT cable distribution network. In sum, electrical equipment fed by U.G. cable network are more at risks and vulnerable and they need to be properly safe guarded.

Let me sign off here.

(viii) References – (1) Paper Tilted "Commercial Building requires voltage stabilizers at the EB incoming to ensure electrical safety and to achieve energy savings" by Er. Ashok Sethuraman, Energy Auditor

(To be continued)



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NEUTRAL EARTHING SYSTEMS OF GENERATOR SETS - (GENSETS)

Earthing of Generator Set

Generator sets have specific features that must be taken into consideration for protection against electric shocks. Mobile sets cannot be connected to earth and their connection by means of a flexible cable can be easily damaged.

Fig 1. Neutral Earthing Systems of Generator sets (Gensets)

In general, generator sets have much lower short-circuit levels than transformers (**around 3×In instead of 20×In**). As a result, the tripping conditions required for protection against indirect contact cannot be provided by devices sized for operation on the normal supply.

Contents:

1. Portable Generator Sets
2. Mobile Generator Sets for temporary installations
3. Mobile Generator Set for fixed installation for one-off re-supply
4. Mobile Generator Set for fixed installation for re-supply planned at the design stage
5. Fixed Sets for fixed installations

1. Portable Generator Sets

For temporary installations limited to a **few kVA**, these supply directly a small number of receivers (market stall, kiosk, power supply for portable tools, etc.).

The exposed conductive parts of the set and those of the installation must be linked together by means of a protective conductor. Each outgoing circuit must be protected by a **residual current device iΔn $\leq$ 30 mA**.

If the set has one or more power sockets without a protective RCD, there should be one RCD per circuit at less than 1 metre. as earthing is not possible and the neutral pole is not accessible, the installation will operate as an IT system

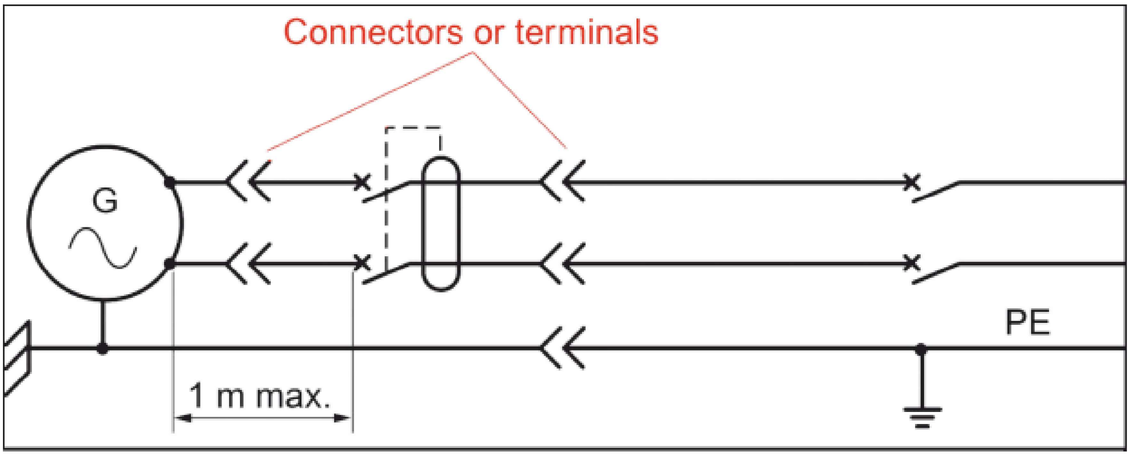


Fig 2. Portable Generator Set Neutral Earthing System

If the generator set supplies **class II devices** - electrical appliances which uses reinforced protective insulation in addition to basic insulation. Hence, it has been designed in such a way that it does not require a safety connection to electrical earth (ground). The exposed conductive parts are not linked, but the provision of one or more RCDs remains mandatory for supplementary protection against direct contact, on the flexible connecting cable.

2. Mobile Generator Sets for Temporary Installations

With powers greater than 10 kVA, these supply larger installations . The exposed conductive parts of the set must be linked to the exposed conductive parts of the devices being used by means of a protective conductor.

Protection against electric shocks is provided by a **residual current device iΔn $\leq$ 30 mA** protecting all the outgoing lines, usually incorporated in the set by construction.

If there are requirements for differential discrimination between the circuits supplied, *secondary residual current devices* iΔn $\leq$ 30 mA can be installed on each outgoing line, as long as they are at a distance of less than 1 m.

*If there is a possibility of **establishing a reliable earth connection, the installation can operate in TN-S system mode.** The fault current is closed by the neutral or by linking the exposed conductive parts if the neutral is not distributed. This is possible for three-phase loads only, and enables three-pole devices to be used. In this case this is a TN-S system with non-distributed neutral, which should not be confused with a TN-C system.*

If there is no earth connection established on the set, the installation will operate as an IT system. The breaking and protection devices must have staggered opening of the neutral with protection of all the poles. In addition, the cross-section of the neutral must not be reduced.

*"**Note:** The installation and setup of generator sets are subject to **specific regulations on the characteristics of the areas,** the discharge and pollutant levels of the exhaust gases, and the permissible noise. It is advisable to refer to these regulations with the assistance of the manufacturers and competent bodies*".

3. Mobile Generator Set for fixed installation for one-off re-supply

Temporary one-off re-supply of a fixed installation instead of the mains supply or the usual power supply should only be carried out after isolation.

Manual opening of the main circuit-breaker generally provides this separation, as long as it is held in position (locking, padlocking) or indicated by a warning sign.

*In all systems (TT, IT, TN) the exposed conductive parts of the generator set must be **interconnected with the earth network of the existing installation**. If a local earth connection can be established for the set's neutral, the earth must be interconnected with the equipotential link of the installation.*

If, as is often the case, this operation is not possible or not carried out, the installation will operate as an it system if the generator's neutral is not accessible.

If the generator's neutral is accessible, it must be linked to the protection circuit of the fixed installation via a protective conductor (with an identical cross-section) incorporated in the cable or via a separate cable sized for the fault conditions, **with a minimum copper cross-section of 16 mm^2. The installation will then operate as a TN-S or TT system.**

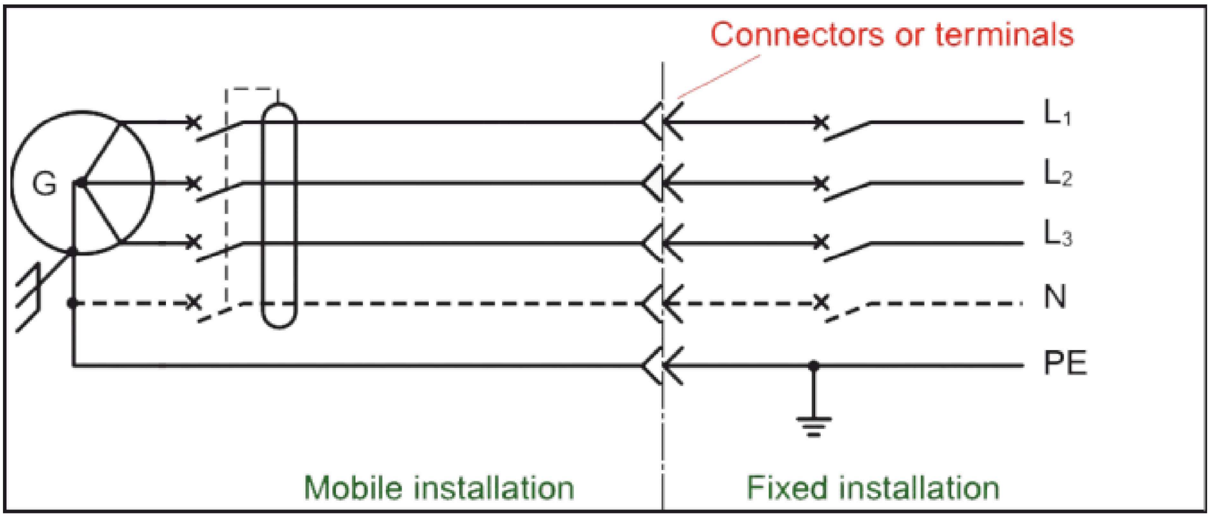


Fig 3. Mobile Generator Set for fixed installation for one-off re-supply

Important Caution: In TN or IT systems, protection against indirect contact may not be provided. In installations that are to be re-supplied by a mobile generator set, a sign must be placed close to the connection point, with the wording:

"Minimum power of the set to be installed: ___ x kVa ."

In all systems (apart from TN-C), the provision of a residual current protection device is recommended. The *residual current toroid* sensor must be placed downstream of the earthing of the neutral point (see Figure 3) or on the generator's neutral point earth conductor.

If the generator is a power supply for safety services, the earthing system used will be the IT system.

4. Mobile Generator Set for fixed installation for re-supply planned at the design stage

When the re-supply of a fixed installation in place of the mains supply or the usual power supply is planned

Fig 4. Mobile Generator Set for fixed installation

at the design stage, **an all-pole supply inverter must be installed.**

Irrespective of the neutral earthing system of the fixed installation, it is necessary to interconnect the exposed conductive parts (TT, IT), the neutral point of the set and the exposed conductive parts of the set (TN) to the exposed conductive parts of the existing installation.

If the protection conditions are not met by the overcurrent protection devices (IT and TN systems)or cannot be determined (see Figure 5), **a high sensitivity residual current device (30 mA) must be used** and the neutral earthed upstream of the RCD (see diagrams below).

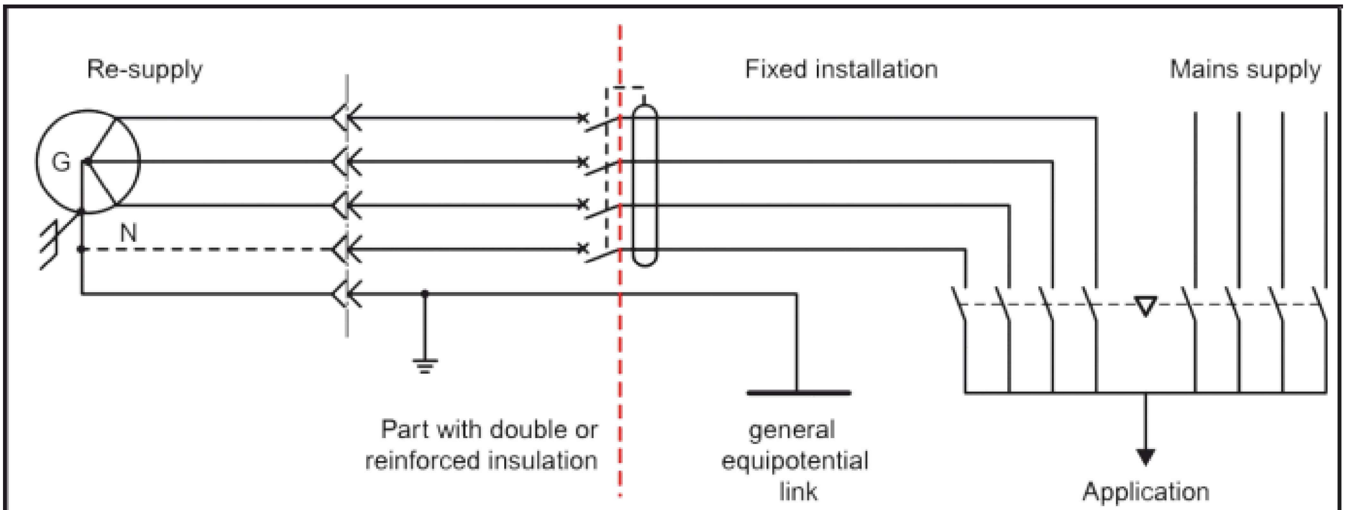
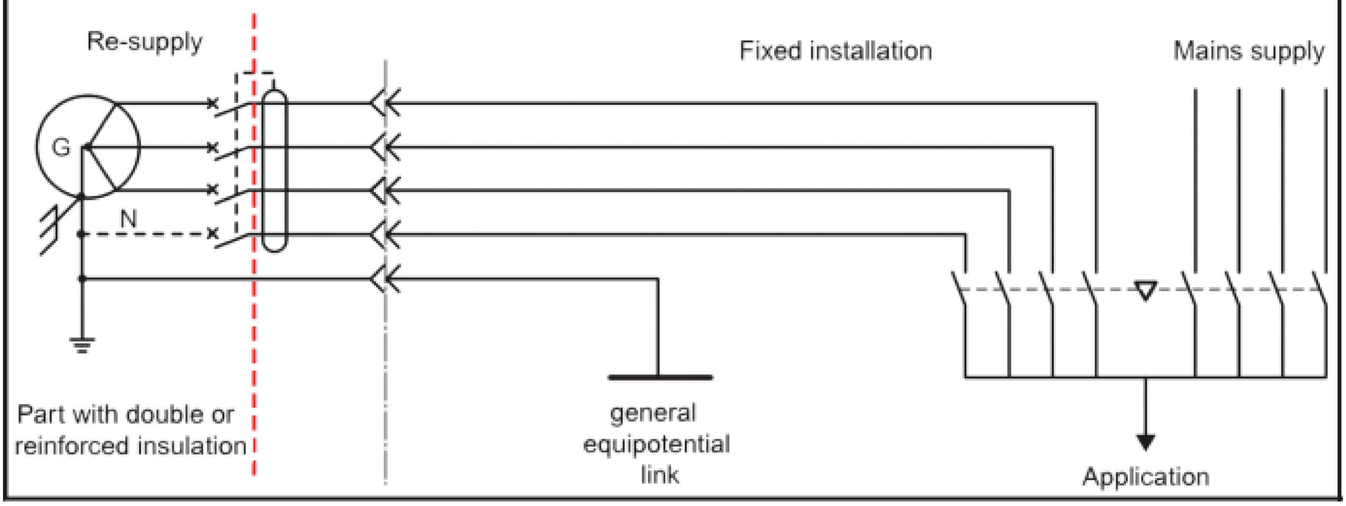


Fig 5. Rules for installing a mobile generator set for fixed installations



In TT systems, an RCD must be used in all cases. The part upstream of the residual current device must have double or reinforced insulation. The toroid sensor must be placed on all the *live conductors (phase + neutral)* or on the conductor linking the neutral point on the alternator to the earth of the installation (TT or TN-S).

This solution is **not applicable in TN-C systems**.

When a generator set supplies a standalone installation with no power sockets or whose continuity of service is paramount (machine, crane, carousel), it is permissible not to install a residual current device **as long as the conditions for protection against indirect contact are met** in line with the chosen neutral earthing system.

Less Fire Security, more Hazard;
More Fire wellbeing No Hazard

5. Fixed sets for fixed installations

If the set is a replacement supply, it must use the same neutral earthing system as the normal supply.The conditions for protection against indirect contact and tripping for *minimum short circuits* must be checked, and must be met each time the installation is supplied by the normal supply and by the generator set.

Safety installations should preferably be created with it systems or under TN system conditions.

Fig 6. Caterpillar Fixed Generator

5.1 Conditions for protection against short circuits and indirect contact

The setting or rating of the overcurrent protection devices that provide protection against indirect contact when using a neutral earthing system for a generator set must be chosen with care, the low value of the fault current is not always compatible with the fuse breaking time.

The rated current in these fuses and that of the generator must be similar **and it is essential that the tripping conditions are checked periodically .**

Likewise, if circuit breakers are used, the magnetic operation adjustment (short delay) must be set to a low threshold.

Courtesy: *Edvard Csanyi*

Electrical Engineer, Programmer and founder of EEP

What is a Soul? It's like electricity – we don't really know what it is, but it's a force that can light a room.

– RAY CHARLES

PASSIVE FIRE PROTECTION SYSTEMS OF ELECTRICAL EQUIPMENT AND OTHER UTILITY SERVICES - PART - II

PASSIVE FIRE PROTECTION – CONTINUATION TO EARLIER JOURNAL

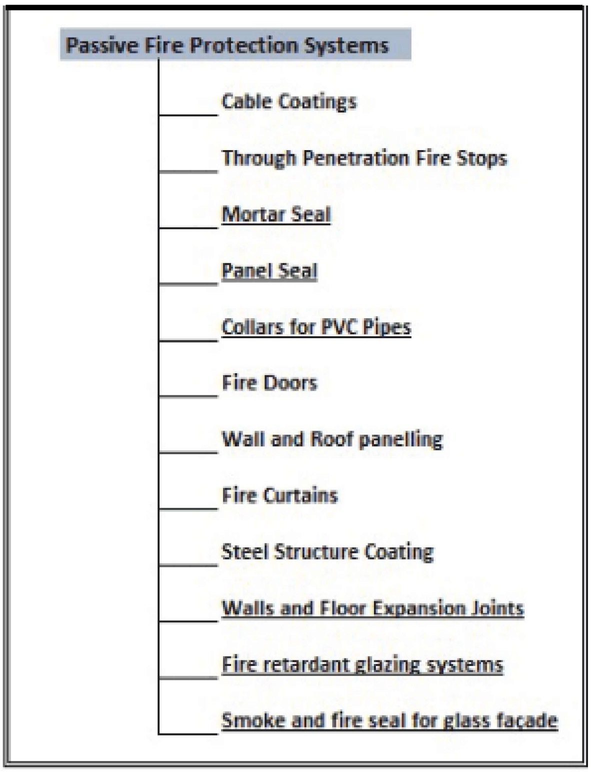
Am happy to inform that some our fine members enquired why I have indicated only passive fire protection for electrical equipment while there are more passive fire protection systems, all being important and applicable to EIectrical substations, data centers etc. also?

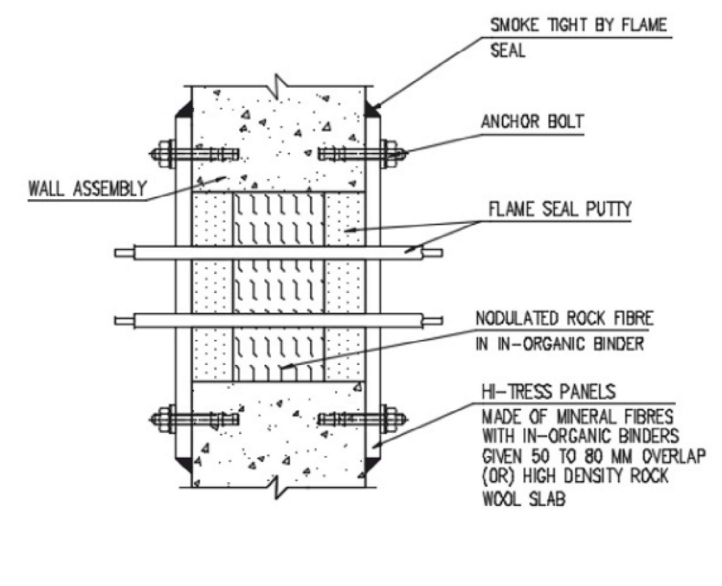
I am very very happy and grateful to them for going through the article and soliciting me to go further. I am indebted to them.Accordingly revising the earlier table and furnished herewith. The new items are underlined for reference.

The sketches of the CABLE COATINGS, THROUGH PENETRATION FIRE STOPS AND FIRE DOORS, INSULATED WALL AND ROOF PANELLING were furnished earlier please.

Presently, the Sample arrangement of the following are furnished:

- **THROUGH-PENETRATION FIRE STOPS (COMBINATION OF CABLE COATING, HI-TRESS PANELS, FLAME-SEAL PUTTY, NODULATED ROCK FIBER IN IN-ORGANIC BINDERS)**
- **COMBINATION OF FIRE DOORS, FIRE SAFE ROOF / WALL PANELLING, FIRE DAMPERS, THROUGH-PENETRATION FIRE STOPS**



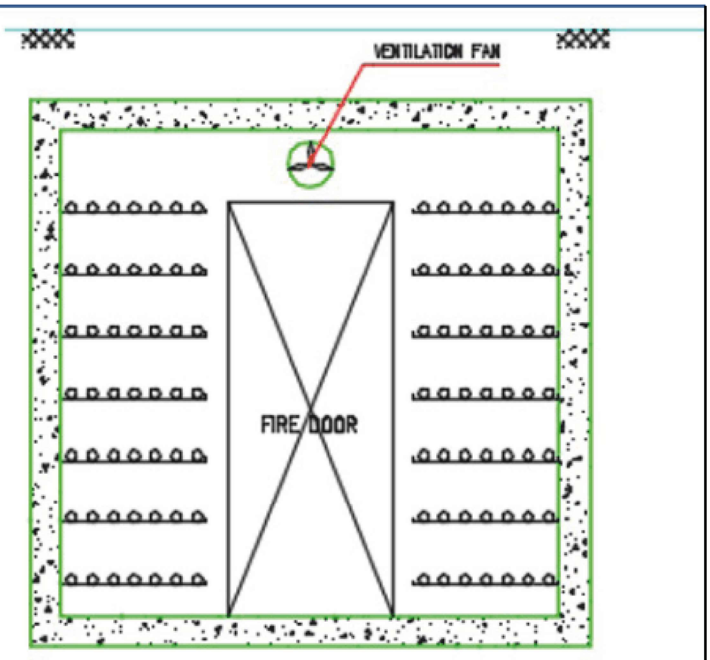


SAMPLE ARRANGEMENT OF THROUGH-PENETRATION FIRE STOPS

(COMBINATION OF CABLE COATING, HI-TRESS PANELS,

FLAME-SEAL PUTTY, NODULATED ROCK FIBER IN IN-ORGANIC BINDERS)

SAVE ELECTRICITY
not just for the money
for our earth which is
suffering from GLOBAL WARMING.



COMBINATION OF FIRE DOORS, FIRE SAFE ROOF /
WALL PANELLING, FIRE DAMPERS,
THROUGH-PENETRATION FIRE STOPS

Furnished below are the sample list of standards.

SAMPLE LIST OF STANDARDS

1	**Sealing of ventilation ducts, Metallic and Non-Metallic Piping**	
	Testing Standard	**UL 1479 ASTME 814**
	Fire Rating	**2 Hours Fire Rated**
	System Material	**LCI Intumescent Sealant & Mineral Wool**
	Material Approval	**UL, FM Approvals etc.**
2	**Cable Coating**	
	Testing Standard	**UL 1479, ASTME 814, FM CLASS 3971**
	Fire Rating	**2 Hours Fire Rated**
	System Material	**LCI Intumescent Sealant & Mineral Wool**
	Material Approval	**UL, FM Approvals etc.**

3	**Wall penetration fire stop systems**	
	Testing Standard	**FM CLASS 4990**
	Fire Rating	**2 Hours Fire Rated, 4 hour rated etc.**
	System Material	**Cement based Mastik Compound**
	Material Approval	**UL, FM Approvals etc.**
4	**Building Panels and Interior Finish Materials**	
	Testing Standard	**FM CLASS 4880**
	Fire Rating	**Class 1**
	System Material	**Steel panelling with insulating cores, sealants, gaskets and caulking**
	Material Approval	**UL, FM Approvals etc.**
5	**Exterior wall systems**	
	Testing Standard	**FM CLASS 4881**
	Fire Rating	**Class 1**
	System Material	**Steel panelling with insulating cores, sealants, gaskets and caulking**
	Material Approval	**UL, FM Approvals etc.**

Furthering Note:

The standards, the tendering specifications are very beautiful. The responsibility for the vendors, the contractors, the client and the maintenance personnel of the client all have major responsibilities to implement the systems.

Any of our readers who requires the user specification is fully welcome to contact me and I will share the specifications without any commercial implications.

Closing Note:

Let us all of us understand and implement proper fire protection systems to improve Life and Property Safety. All the best to our readers.

Mr. Muthukrishnan Kalyanasundaram, M.E.

Proprietor – M/s HKM ENGINEERS AND CONSULTANTS

Services - Fire and Life Safety Consultancy

Email id - mr.k.muthukrishnan@hkmconsultants.com

Contact Number - 9930265069

(Son of Mr. H.Kalyanasundaram – Ex. Best and Crompton Engineering Limited)

The day when we shall know exactly what electricity is will chronicle an event probably greater, more important than any other recorded in the history of the human race. The time will come when the comfort, the very existence, perhaps, of man will depend upon that wonderful agent.

– NIKOLA TESLA

6. COMPENSATION

6.1 INTRODUCTION

The voltage drops in an A.C. electric power supply system, caused by problem loads which are large compared with the short circuit level of the system, is mainly due to reactive component of the load I_q flowing through the system reactance X_o i.e. $V = I_q X_o$. The variations in loads can cause voltage fluctuations and consequent objectionable or irritating light flicker.

These troublesome loads sometimes produce harmonic currents, which are large enough to cause distortion problems to other consumers whose electricity supply is provided from the same busbar (the point of common coupling). To provide reactive VAr control in order to support the power supply system voltage and to filter the harmonic currents in accordance with Electricity Authority recommendations, which prescribe the permissible voltage fluctuations and harmonic distortions, reactive power (VAr) compensators are required.

These compensators can be grouped into two major groups these are synchronous compensators (condensers) and static VAr compensators. The static VAr compensators having no moving parts. The speed of response of the synchronous compensator is low and the cost is high when compared with the static VAr compensators and hence the latter are the preferred solution.

6.2 WHAT ARE STATIC VAr COMPENSATORS

Static VAr compensator (SVC) is a shunt connected static VAr generator or absorber whose output is adjusted to exchange capacitive or inductive current to maintain or control specific parameters of the electrical power system (typically bus voltage).

At least four different types of static VAr compensator (SVC) are available. These are saturated reactor type compensators, thyristor controlled reactor compensator and thyristor switched capacitor compensator and STATCOM (Static Compensator).

6.3 SATURATED REACTOR TYPE COMPENSATOR

The Power Transmission Division of GEC, Stafford, was the pioneer of saturated reactor type compensator. The saturated reactor type compensators were first developed in the 1960’s by AREVA (then GEC) under the guidance of Dr. E Friedlander. These are transformer type devices, which were built in the factory of AREVA (then GEC) Transformers Limited in Stafford. Unlike a synchronous machine the saturated reactor has no rotating parts, no inertia and inherently remains in synchronism with the supply. A saturated reactor can only absorb reactive power. It does not need any external control to force it to absorb reactive power. It does so by the nature of the saturation feature of the magnetising characteristic of its core iron as it operates normally in saturated flux region. The saturated reactor is inherent in its response and the speed of response is fast. The reactive power required for compensation is generated by parallel connected shunt capacitance (often in the form of tuned or damped harmonic filters). The order of harmonic filters depends primarily on the harmonic (number) currents generated by the troublesome loads. There are different types of saturated reactors, namely twin tripler reactor, treble tripler reactor and tapped reactor. AREVA have so far designed, manufactured and commissioned forty-nine saturated reactor type compensators all over the world. AREVA are the only Company in the World which produce both the saturated reactor type compensators and the thyristor controlled type compensators.

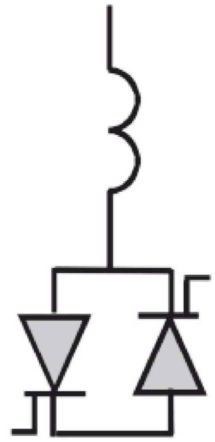
6.4 THYRISTOR CONTROLLED REACTOR COMPENSATOR (TCR)

Thyristor controlled reactor (TCR) is a shunt connected thyristor controlled inductor whose effective reactance is varied in a continuous manner by partial conduction of the thyristor valve.

The thyristor controlled reactor comprises a linear reactor, connected in series with a ‘thyristor valve’ made up of inverse-parallel (back-to-back) connected pairs of high power, high voltage thyristors.

Unlike saturated reactor (which is inherent, and does not need any external control), the variation of current in the linear VAr reactor (for VAr absorption) is obtained by control of the thyristor conduction duration in each half cycle. The firing angle delay is 90° as measured from the applied voltage zero for full conduction, and can be varied up to 180° delay for no conduction.

In saturated reactor the current is 'switched' by core saturation. In a TCR the current is switched by thyristors. As in the case of a saturated reactor compensator, the reactor power required by the loads is generated by parallel connected shunt capacitance (as mentioned above, often in the form of harmonic filters). During system light load conditions, the excess reactive power from this shunt capacitance is absorbed by thyristor controlled reactor. The design of the harmonic filters depends on the harmonic generated by both the thyristor compensator and the problem loads. The major harmonic frequencies which the TCR produces in the a.c. supply depend on the pulse number p, (e.g. p = 6) in accordance with the formula $h = kp \pm 1$ where h stands for the harmonic number and k is a positive integer. AREVA (then GEC Alstom) have manufactured and commissioned TCR compensators for transmission system applications.

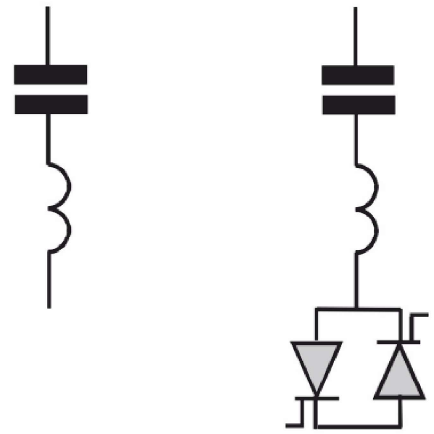


Thyristor Switched Capacitors

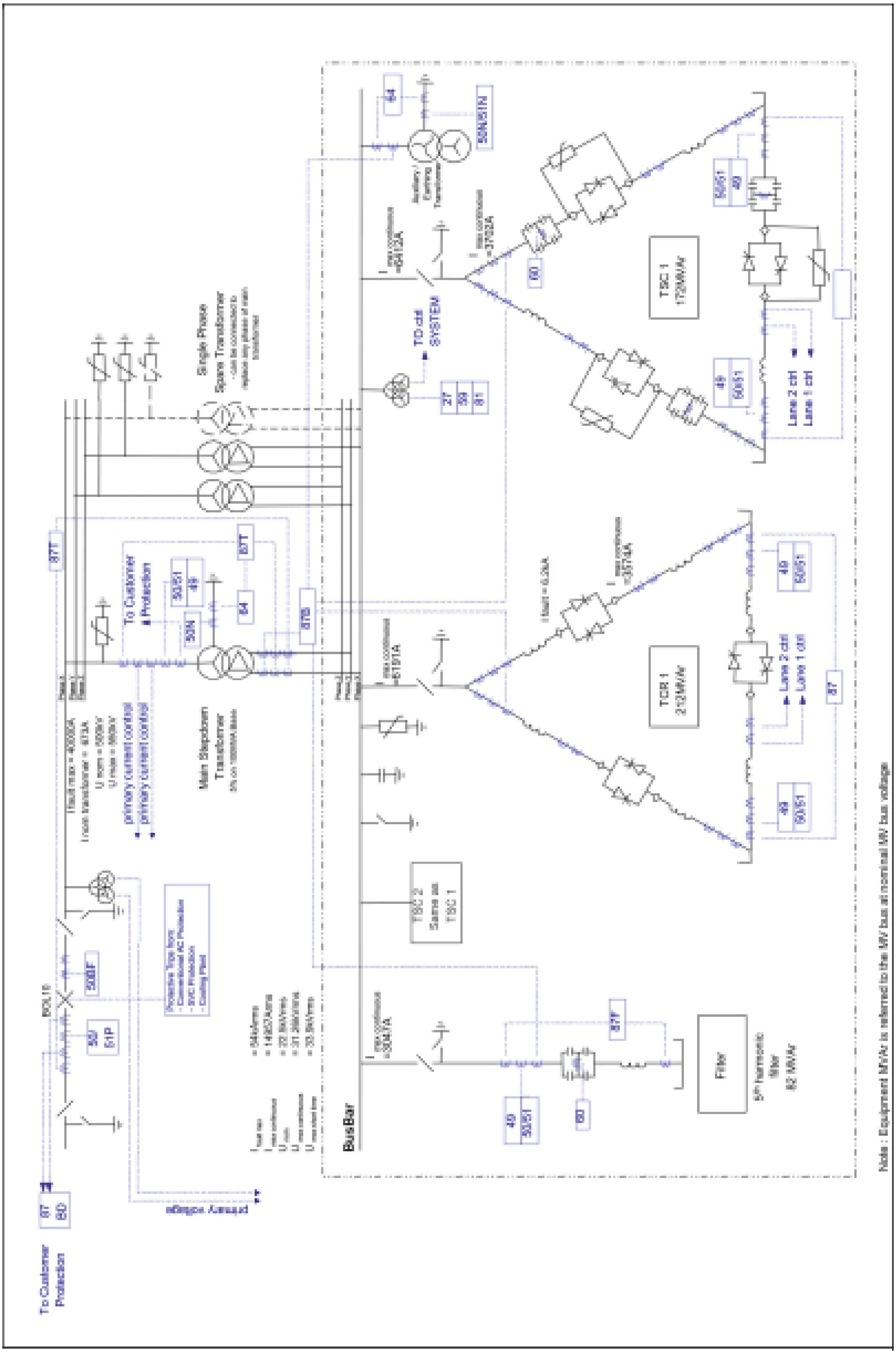
6.5 THYRISTOR SWITCHED CAPACITORS (TSC)

Thyristor Switched Capacitor (TSC) is a shunt connected thyristor switched capacitor whose effective reactance is varied in a stepwise manner by full or zero conduction operation of the thyristor valve.

Thyristor valves consisting of inverse-parallel connected thyristors, generally similar to those used for the TCR, are used to give rapid switching of blocks of capacitors. The capacitors are switched in block only, i.e. step-by-step, as they cannot be firing angle controlled, unlike the TCR, as excessive capacitor inrush currents would result. After the capacitor current through the thyristor ceases at current zero, unless re-gating occurs, the capacitors remain charged at peak voltage while the supply voltage peaks in the opposite polarity after a half cycle. The decay of the stored charge takes several minutes and this imposes a doubled voltage stress on the non-conducting thyristor and an increase is necessary in the number of thyristors in series in a TSB.



Fixed Capacitor   Thyristor Switched Capacitors


BusBar
Main Stepdown Transformer
Single Phase Spare Transformer
TCR 1
212 MVAr
TSC 1
TSC 2
Same as TSC 1
Filter
TO ctrl SYSTEM
To Customer Protection
primary voltage
primary current control
Lane 2 ctrl
Lane 1 ctrl
Note : Equipment MVAr is referred to the MV bus at nominal MV bus voltage

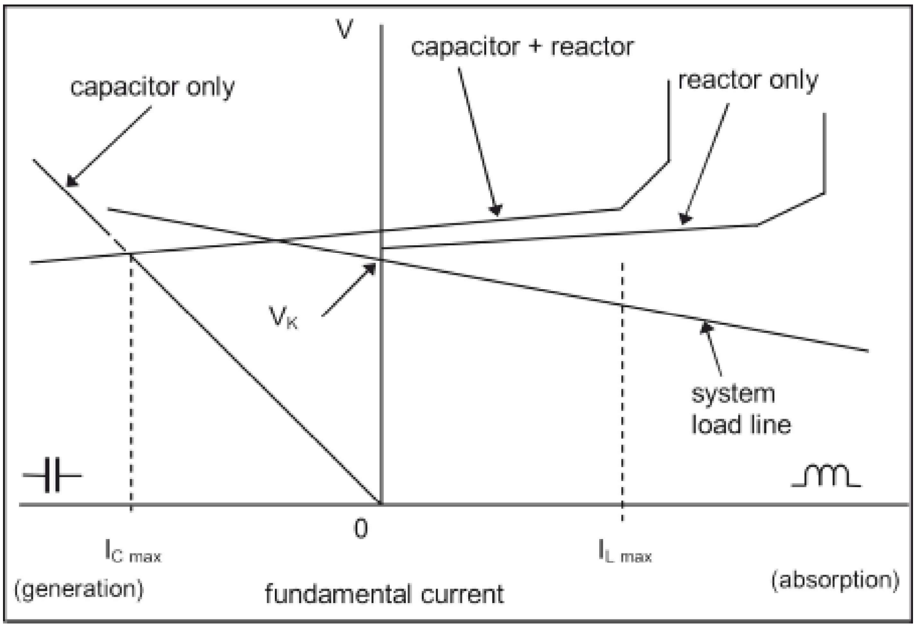
6.6 STATIC VAr COMPENSATOR

The general arrangement of the Static VAr Compensator is shown on the next page. It consists of Thyristor Controlled Reactors (TCR) in parallel with thyristor switched capacitors (TSC). The reactive equipment's of the compensator are connected to the transmission line, through a transformer to prevent the equipment's having to withstand full system voltage. A control system determines the exact gating instants of reactors according to predetermined strategy. The strategy usually aims to maintain the transmission line voltage at a fixed level.

To provide both inductive and capacitive power, the TSCs are included with TCRs. The combined arrangement of TCRs and TSCs is now capable of providing a range of leading and lagging reactive power to support the required operating voltage range.

The continuous variation in the TCR is used in combination with the stepped effect of switching in or out integral capacitor units in the TSC to achieve an effective continuous variation of reactive power over the whole operating range. The typical characteristics of the combined TCR and TSC, the static VAr compensator (SVC) are shown in the figure on the previous page.

Static VAr compensators are used to help power transmission over long A.C. transmission lines by injecting reactive power at points down the line to maintain voltage levels. AREVA (then GEC Alsthom) have designed, manufactured, installed and commissioned SVC's on transmission systems worldwide and are mainly used for dynamic voltage and reactive power support at load centres remote from generating plant.



The figure above shows the typical characteristic of the combined compensator. This arrangement is now capable of providing a range of leading and lagging reactive power support to its operating voltage.

6.7 STATCOM (STATIC COMPENSATOR)

A static synchronous generator operated as a shunt connected static VAr compensator (SVC) whose capacitive or inductive output current can be controlled independently of the A.C. system voltage. STATCOM is based on a voltage source converter. STATCOM has superior dynamic reactive power compensation ability and wider operating voltage range, then a normal SVC. The phases of the STATCOM are independently controlled during system disturbances.

(To be Continued)

Courtesy: V. Ayadurai Bsc, C.Eng, FIEE

Engineering Expert

ELECTRICAL MAINTENANCE UNIT
(QUESTION & ANSWERS) – 17

Protective relays and application

1. What you mean by accuracy limit factor?

   The ratio between the accuracy limited primary current to rated primary current is called the accuracy limit factor.

2. What is the characteristic of inverse time over current relay?

   If the fault current increases the time of the operation of the relay will be decreases.

3. What are the two errors in instrument transformer?

   a. Ratio error.

   b. Phase angle error.

4. Where core balance CT is used?

   Core balance CT is used in earth fault protection.

5. Define knee point voltage of a CT.

   When the primary of a CT is open circuited and supply (variable) of system frequency is given to secondary, then a 10% increase in voltage constitutes 50% increase in current. That voltage is the knee point voltage.

   At this point the core is saturated and a little increase in voltage constitutes a great increase in current. kpv decides the opening range of the CT. Above kpv the ratio of transformer will not be applicable.

   kpv = $R_{CT} + R_{LEADS} + R_{RELAY}$

6. What do you mean by the term 5P10?

   This indicates the type of relay, Its % error and accuracy limit factor.

   5 – composite error (Phase angle error + ratio error) 5%.

   P – Protection CT.

   10 – Accuracy limit factor.

7. Mention the important properties of relay contacts.

   a. Should be robust in construction.

   b. Self-cleaning (oxides easily breakdown).

   c. Corrosion resistant.

   d. Bounces free and striction free (low contact resistance).

   e. Able to carry rated continuous current and short time rated current.

8. What is a composite error and write down the formula for composite error?

   Basically composite error = Ratio error + Phase angle error. It is the ratio error integrated over one cycle at steady state of operation.

$$Composite\ error\ = 100^{*}\sqrt{\frac{1}{T}o\varsigma^{T}\,\frac{\left(K_n * I_s - I_p\right)^2}{I_p}\ dt}$$

9. Define pickup value and reset value.

Pickup value: It is the smallest value of actuating quantity when its value is increased from zero to pickup value, the relay will energise.

Drop out value: It is the largest value of the actuating quantity when its value is decreased from pickup value, the relay will reset or de-energize.

10. Draw the circuit diagram for finding out the knee point voltage and explain the procedure.

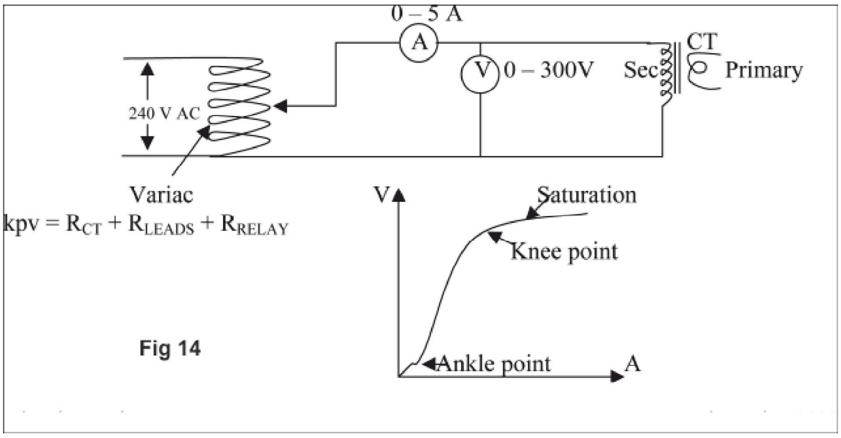


Fig 14

Connect the circuit as shown. O/P of variac should be zero. Increase it to 5 Volts and take down the value of current from the ammeter. Now increase the voltage by 10% (5 + 10% = 5.5 V) and take the current reading. Now increase the voltage by 10% (5.5 V +0.55 V =6.05 V) and note down the current. Now keep on increasing voltage by 10% and note down current reading. At some value there will be 50% increase in current for 10% increase in voltage.

Example 40 V ⟶ 0.2 A

40.4 V ⟶ 0.3 A (0.2 + 50% = 0.3 A).

That point is the knee point voltage of that particular CT. From this point onwards a little increase in voltage will lead to a large increase in current, because the core is saturated fully. When we plot all the values on a graph taking current as X-axis and voltage as Y-axis, we will get the above graph. Protective relays operate between ankle point and knee point. Above this they cannot detect the fault correctly. Measuring CT operate in the ankle region.

11. Explain the procedure for finding out the polarity and ratio test in a CT with circuit diagram.

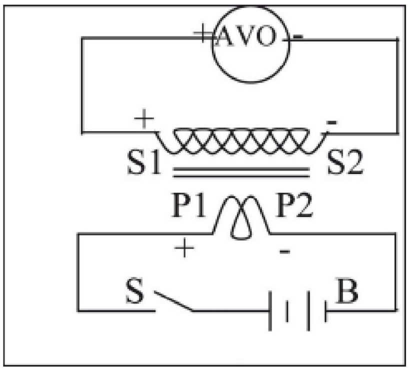


Fig 15 - Polarity Test

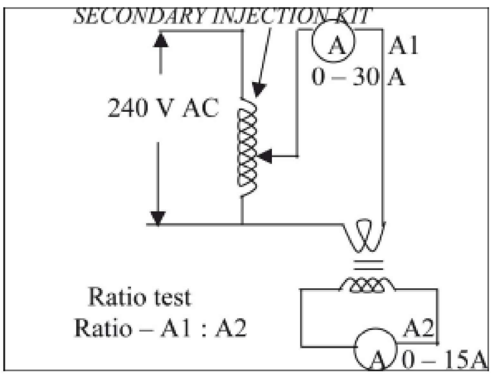


Fig 16 - Ratio Test

Polarity test: Connect the circuit as shown in figure with a battery, switch and AVO meter. Now momentarily close the switch S and see the deflection in the AVO meter. If it is in the direction as shown in the figure, then the polarity of the CT is correct. If it is in opposite direction the polarity of CT is not correct. Polarity test is very important because if polarity is not correct in differential protection the relay will fail to act when fault occurs.

Ratio test: Connect circuit as shown in figure (2). Slowly increase the current. Take down the readings of A1 and A2. Then see whether it confirms to reading of nameplate. Ratio = A1/A2.

12. Explain the principle of operation of attracted armature relay with equation and characteristics curve.

Principle: It works on the principle that when a current is passed through a coil magnetic lines of force develop and the coil behaves like a magnet. When we place a magnetic material inside the coil it is attracted.

In attracted armature type of relays there is a spring that keeps the contact open, a plunger that tends to close the contact and a coil through which current is passed. The spring force and magnetic force oppose each other. When these both are equal the relay will pickups.

At verge (time) of pickup

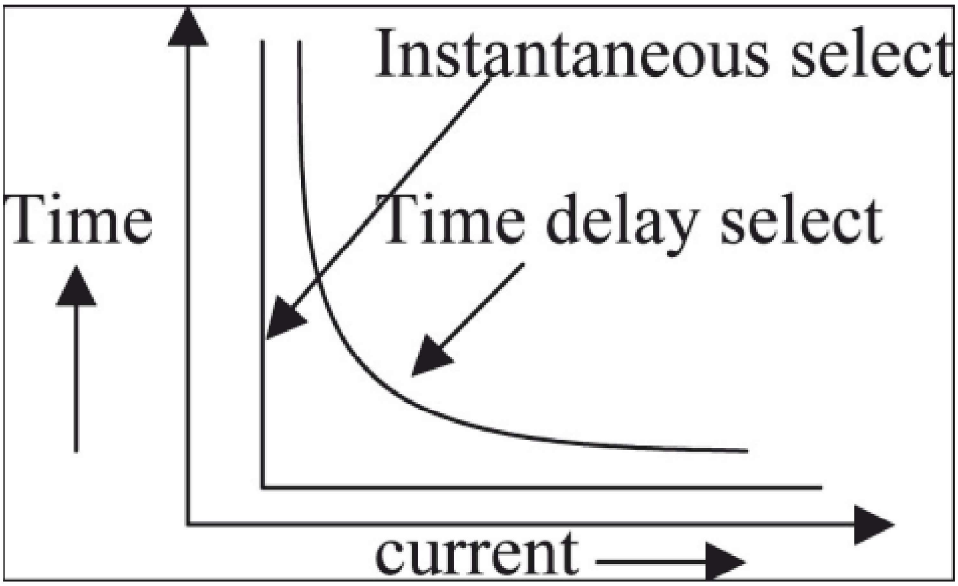


Fig 17

$K_1 I^2 = k_2$

$f = k_1 I^2 = k^2$

$I = \sqrt{k_2/k_1}$

Where f – force

k_1 – magnetic force constant

k_2 – Spring tension constant

I – Current in the coil

We can see the inverse characteristics from the above formulae. Usually attracted armature relays are instantaneous. That is there is no intentional (fixed) time delay. If we want a time delay, we can add a slug in the armature core.

13. Mention the initial commissioning checks on CT's, PT's and relays.

Commissioning checks on

CT

a) Terminal marking correctness.

b) Polarity of terminals.

c) Insulation resistance between primary and secondary.

d) Insulation resistance between primary to earth and secondary to earth.

e) Magnetization characteristic and knee point voltage test.

f) Ratio test.

PT

a) Terminal markings.

b) Polarity checks of terminals.

c) Insulation resistance between primary and secondary.

d) Insulation resistance between primary to earth and secondary to earth.

e) Ratio test.

f) Whether PT can supply as per the burden of load check.

RELAYS

a) Pickup and dropout value check.

b) Insulation resistance of contacts and relay coil.

c) Time delay (if relay is not instantaneous), operating time value check of relay.

d) See that the correct circuit breaker trips on energisation of the particular relay.

e) Continuity checks of contacts after energisation of relay.

f) See if plug-shorting contacts are correct.

g) See if CT's and PT's are corrected in correct polarity.

h) Burden check of relay.

i) Primary injection test.

j) Secondary injection test.

14. Explain with simple diagram the core balance CT.

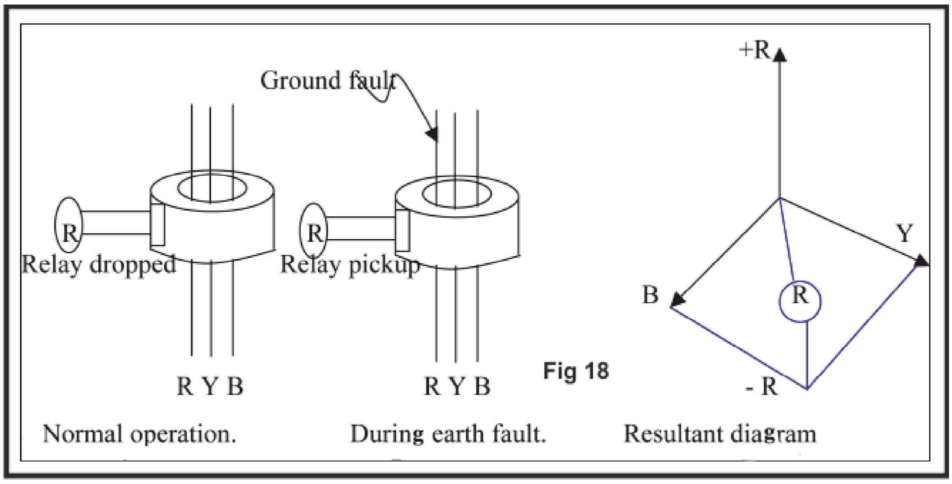


Fig 18

In core balance CT all the three phases go through the core and the resultant magnetic flux is zero. Because the flux of three phases cancel each other. So the secondary output of CT is zero and the relay will not energise.

When there is a earth fault in one of the phase the fluxes cannot balance each other and there is a voltage induced in secondary of the CT and the relay is energised to trip the circuit. Saturation is no problem because the core size is very big.

Logics and circuits

1. Give the definition of following.

27C	Closing circuit supervisory relay
27T	Tripping circuit supervisory relay
3C	Interposing relay (closing coil)
3T	Tripping coil
52	AC circuit breaker
88	Auxillary motor (spring charging motor)
52Y	Anti-pumping relay
86.1	Lockout relay
42	Main contactor
50	Instantaneous over current relay
50N	Earth fault relay
94	Trip or Trip free relay
49	Thermal overload relay
49S	Stalling protection relay
27	Supervisory relay
64	Ground protection relay

2. What is the operating voltage of 3C?

   48V DC.

3. DC relay coil or contactor coils must be connected to which side?

   Negative side of the DC supply to avoid galvanic effect on the coil, which will corrode the oil.

4. How special current limiting resistance is connected with the seal in contact?

   Special current limiting resistance is connected in series with the seal in contact.

5. How you will connect start and stop push button to control the motor from two different places?

   Start push button should be connected in parallel and stop push button in series in the circuit.

6. What are the basic principles of ED?

   Basic principles of ED are,

   a. All the contacts of corresponding relays and contactors are shown in de-energised condition.

   b. Control circuit gives us idea about ON / OFF selection of motor, fuse rating, forward reverse control, seal in protections etc.

c. Power circuits are drawn in thick lines and control circuits are drawn in thin lines.

d. When relay or contactor energises normally open contact closes and normally closed contact opens.

e. Auxillary contacts acts with main device such as contactors and relay.

7. What is anti-pumping?

When a breaker is closed on fault condition there will be continuous tripping and closing of the breaker because 3C is energized. Anti-pumping in circuit avoids frequent tripping and closing of circuit breaker when the breaker is closed in fault condition.

(To be continued)

Courtesy:https://www.scribd.com/document/244623258/Question-and-Answers -Electrical-intenance-Unit

HUMOUR

WHY ENGLISH IS HARD TO LEARN

We'll begin with *box;* the plural is *boxes,*
But the plural of ox is *oxen*, not *oxes*.
One fowl is a *goose* and two are called *geese*,
Yet the plural of *moose* is never called *meese*.
You may find a lone mouse or a house full of mice;
But the plural of house is houses, not hice.
The plural of man is always men,
But the plural of pan is never pen.
If I speak of a foot and you show two feet,
And I give you a book, would a pair be a beek?
if one is a tooth and a whole set are teeth,
Why shouldn't two booths be called beeth?
If the singular's this and the plural is these,
Should the plural of kiss be ever called keese?
We speak of a brother and also of brethren,
But though we say mother, we never say methren.
Then the masculine pronouns are he, his and him:
But imagine the feminine … she, shis and shim!

-Anonymous

When I was in class 7, I used to ask a lot of questions. …..!

One day, I asked my English Teacher, "why do we ignore some letters in pronunciation eg, the letter H …. In Hour, Honour, etc ….. ?????

My English Teacher said, "we are not ignoring them; they're considered silent" ….. (I was even more confused …. ?????)

During the lunch break, my Teacher gave m packed lunch and asked me to heat it in the cafeteria.

I ate all the food and returned her the empty container. ….!!!!!

My English Teacher: What happened? I told you to go and HEAT my food, you are returning me an empty container.

I replied, "Madam, I thought 'H' was silent.

Dedicated to all English Teachers.

An English Teacher wrote these words on the whiteboard: **"Woman without her man is nothing."**

The teacher then asked the students to punctuate the words correctly.

The *Boys* wrote: **"Woman, without her man, is nothing."**

The *Girls* wrote: **"Woman! Without her, man is nothing."**

Once you got a Solar Panel on a roof, Energy is free. Once we convert our entire Electricity grid to Green and Renewable Energy, cost of Living goes down.

– ELIZABETH MAY

You cannot define electricity. The same can be said of art. It is a kind of inner current in a human being, or something which needs no definition.

– MARCEL DUCHAMP

HOME FESTIVALS - 6

ஆனி - Aani (June/July)

This is the one month of the year when there are no home festivals — coinciding not uncoincidentally with an intense month of agricultural effort. However, during Aani, major temple festivals are held for Lord Siva as Nataraja, King of Dance (left), and for Siva and Parvati.

HOME FESTIVALS - 7

ஆடி - Aadi (July/August)

There are two major home festivals this month. The first is **Adi-Perukku**, in honour of the Kaveri River. Women and girls go to the nearest river where they place offerings on a bamboo tray (upper left) into the water, then have a feast upon the riverbank. **Varalakshmi Vratam** ("Vow to bring Lakshmi") is also a ladies' festival, in which paintings of the Goddess of Wealth are made upon the walls (upper right), kumbha pots intended for worship are decorated with Her image. Beside the pot are placed various cosmetics, comb, beads, etc and worship is done. Then the ladies sing songs inviting the Goddess to their home. Kozhukkatai, rice and jaggery cakes are a favourite of the day. In the evening, friends are invited to the home and given clothing, coconuts and sweets.

(To be continued)

"It is health that is the real wealth, and not pieces of gold and silver."

– MAHATMA GANDHI

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