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S P E NEWS LETTER

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THE SOCIETY OF POWER ENGINEERS (INDIA)

(VADODARA CHAPTER) ESTD. 1996
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Er. N. Dinker

COVERPAGE THEME - GO GREEN

From The Chairman's Desk

The general elections have been concluded in May 2014 and the new government is formed in India under Prime Minister Narendra Modi, as the result of very clear verdict from people in favour of the single party. It is clear indication that people of India are not in favour of the coalition governments. Lack of consensus amongst the coalition partners led to the hurdles and bottlenecks for many reforms under taken, damaging and slowing down India's progress.

The people of India and the power sector have high expectations from new government and believe that it will put the country on high growth track with improvement in the economy.

The power sector in our country has been struggling and facing serious problems due to the weakness and indecisiveness of coalition government during past two decades. The government has to overcome many challenges in Transmission and Distribution sectors. Many reforms provided by Electricity Act 2003, which could not be implemented due to various reasons, must be revisited and amended. The government will have to meet many challenges in distribution sector like tariff rates, payments to generation companies, unmetered supplies to rural areas, theft of electricity etc. which are sensitive issues and have political implications. However, I am sure, the political will and public support will be able to prevail to meet challenges

Electrical equipment industry in India has been facing difficult time for last few years due to reduction of demand from country's power sector and increasing imports of power equipment from other countries. During last few years electrical industry was approaching the government and proactively presenting the issues and challenges faced by them. It is expected that the new government will pay utmost attention to these issues and make adequate provisions in coming budget.

The manufacturing sector is lagging behind in economic growth and the government needs to set up world class investment opportunities and clear policies to promote manufacturing sector and rapidly create jobs for the youths.

12th Five Year plan for energy addition would need lot of coal and transportation infrastructure. The government has to take fast decisions to clear many projects concerning energy sector and also balance concern about their environmental and social impacts.

The rapid growth and fast completion of the stalled projects in electrical sector, will need many trained engineers in India and the sector may face the challenges for training and skill development. The organizations like SPE and the experienced power engineers should be ready to take these challenges.

G. V. Akre
Chairman

Editorial

Power Transmission Network is a link between the power generating companies and the power distribution companies. Substation is an integral part of the power transmission system. The substations in the transmission system have stepdown transformers, called "Power Transformers". The generating stations also have a substation/switchyard with step-up transformers called "Generator Transformers". The difference between the power transformer and the generator transformer is that normally the former has a smaller voltage ratio compared to the later.

The switchyard design comprises Electrical, Structural and Civil Sections. Substation need fire protection system, Air Conditioning, Lighting etc. Electrical design generally include the items of equipment sizing, bus bar sizing, earthing design, single line diagram, plan layout, sectional views, direct lightning protection diagram, erection key diagram, protection design, control and relay panel design, direct current distribution board, alternating current distribution board, battery sizing, diesel generating set etc.

The structural design include gantry structures and equipment support structure. The civil design include control room, cable trenches, gantry column foundations, equipment support structure foundations, transformer/reactor foundations, compound wall, chainlink fencing, culvert, security cabin etc.

Construction of substation/ switchyard also calls for a special skill. Co-ordinated efforts of civil, structural and electrical engineers are needed right from the inception. The design also needs to keep in mind the future development in the proposed substation.

Latest trend in the country is to award EPC contracts for substations. Specifications are drafted covering all the engineering aspects of the substation/switchyard. EPC contractors some times are influenced by the IEC or specifications other than Indian Standards. Sometimes such specifications are proposed for improvement in the reliability of the substation. The smart grid and SCADA is a latest addition to substation automation. The aim is to monitor the entire transmission system on real time basis. This improves reliability of the system and affords quality power to the consumers.

With the central government focusing on power sector, there is going to be boom in the construction of substations. The projected industrial growth will also mean increase in number of substations in the industrial sector too.

Keeping this in view SPE(I), Vadodara chapter has organized a 2-Day National Seminar on 10-11 October 2014 on the topic of "Substation Design, Engineering & Construction" in Vadodara. This seminar is bound to attract power utilities, EPC contractors, consultants, students and teachers from all over the country.

The information bulletin is already under circulation. Response has started pouring in. The Executive Committee, the Advisory Committee and Active Members of SPE(I) Vadodara have geared up individually and collectively to make the programme a grand success. Ofcourse, the blessings from Er. SK Negi, MD, GETCO in the form of knowledge partnership in the seminar, is bound to boost the moral of the organizers.

The reader members may contact SPE(I), Vadodara Chapter office in Avishkar Complex or Er. VB Harani-Secretary, Mobile : 9925238450, Er. SM Takalkar - Editor, Mobile : 9925233951 / 9879599402 for further information.

Er. SM Takalkar - Editor

CHAPTER'S ACTIVITIES

- **On 18 May 2014,** an unique lecture on the topic of Natural By-pass, Angioplasty & Heart Reversing Programme was arranged by the chapter in the Vasvik Auditorium of the Institution of Engineers, Vadodara. The speaker was Dr. Bimal Chhajed from Salo Heart Centre Vadodara.

  The speaker started with the introduction to the functioning of Heart. He stated that the Heart also needs the blood supply, which is provided by the vains around the Heart. When these vains are blocked by cholesterol and triglyceride, supply of blood for the functioning of the heart is affected. This results in to heart attack or heart failure, depending upon the severity of the blockage. The speaker insisted on changing the food habits and avoiding oil and other substances responsible for the blockage. He recommended to keep B.P. & Diabetes under control.

  He further explained as to how the blockage of vain can be found out without angioplasty and how it is possible to have vain bypass without surgery.

  The programme which was attended by the members with spouse, was very well received. There was a pin drop silence during the entire lecture.

- **On 06 & 07 Jun 2014** a National Workshop on "Geotechnical Considerations for Power Equipment Foundations" was organized at IG Patel Seminar Hall, Faculty of Social Work, MSU, Vadodara.

  This event was organized by Indian Geotechnical Society, Vadodara Chapter with support of Society of Power Engineers (I) Vadodara Chapter.

  The Themes of Workshop were as under :

  - Geotechnical aspects for Design and Construction of Power House (Thermal, Hydro, Gas, Wind Mill etc.)
  - Specific geotechnical considerations for Boilers, Turbines, Water boiling Towers, Heavy duty Motors, Tall Chimney etc.
  - Sub-station foundations
  - Transmission line tower foundation
  - Foundation in difficult soil strata
  - Pile foundations for power equipment
  - Vibration isolation techniques

  Dr. AV Shroff-Chairman (Prof. MSU Retd.) and Dr. Nitin Joshi-Secretary (Prof. MSU) IGS Vadodara Chapter were the Principal Co-ordinators.

  As the theme was suggested by SPE(I), Vadodara Chapter the SPE(I) Vadodara Chapter, following members gave their services for the success of Workshop:

  Advisors

  1. Er. GV Akre, Chairman
  2. Er. SB Lele, Vice-Chairman

  Co-ordinator

  1. Er. SM Takalkar, Advisory Committee Member

  Organising Committee

  1. Er. VB Harani, Secretary
  2. Er. KN Rathod, Executive Committee Member
  3. Er. GM Bahudhanye, Office Administration Committee

  Er. SM Takalkar presented 3 papers in the seminar.

  The seminar was a grand success with presence of eminent engineers from power sector of the country.

- **On 20 Jun 2014,** a lecture on the topic of Small Hydro Power Project was arranged at GETRI Auditorium. The speaker was Er. Prakash A Shah, Retd. CE, GETCo and now Practicing Electrical Engineer. He gave overall information of development of Hydro Power Projects from commissioning of India's first hydro power project in Darjeeling. He gave the classification of Hydro Power Projects on the basis of capacity right from Pico(100Watts) to Large Hydro Power Station i.e. Pico, Micro, Mini, Small, Medium and Large Hydro Projects of Country in general and of Gujarat in particular. He explained in detail regarding type of HEP i.e. Dam Toe, Run of River and Canal Diversion. He gave information about existing micro, mini and small HEPs in Gujarat and planning for other HEPs. He also deliberated guidelines regarding approval of various authorities required for setting up HEP. The programme was well received by the members present.

Obituary

Er. RH Shah, Life Member of SPE(I) Vadodara Chapter, passed away at the age of 71 years during first week of May-2014. Er. Shah was Advisory Committee Member of SPE(I) for some years. He served in IOCL (Gujarat Refinery) and retired as Manager(Training).

May God give peace to the departed soul and give strength to his family members to bear the impact.

Future Events

SPE(I) Vadodara Chapter has organized a 2-Day National Seminar on Substation Design, Engineering & Construction at Vadodara on 10 & 11 Oct 2014.

The details of Seminar are given below:

A. Topics to be covered

1. Planning

- Site selection criteria and its significance
- Selection of technologies - AIS, Hybrid or GIS - Cost effective solution on life cycle cost basis.
- Technology and design option for extension / augmentation of substation

2. Design and Engineering

(i) Role of Primary Engineering

- Different switching schemes/Busbar configuration for the space available
- Decision criteria for selection of substation type - AIS, GIS and Hybrid
- Equipment sizing and selection
- Insulation co-ordination
- Electrical parameters for civil design
- Impact of environment and accordingly change in design of substation
- Design calculations and latest software for
  - Earthing
  - DSLP
  - Sag-Tension calculations
  - Battery sizing
  - Illumination
- Mobile substation

(ii) Role of Secondary Engineering

- Protection system, SCADA and Automation
- IT and Communication for integrated solution
- Innovative auxiliary system like DC supply, LT supply, Fire protection etc.

(iii) Role of Civil Engineering

- Design of foundation according to different soil characteristics
- Design criteria for gantry and equipment support structures according to layout
- Ancillary system engineering like contouring, cutting/filling/leveling, storm water drain, culverts, roads, rain water harvesting system etc.

3. Erection, Testing and Commissioning

- Fast project delivery solutions
- Best erection practices and Field Quality Plans
- Resource management - Multi stakeholder/agency integration
- Safety Measures
- Comprehensive test plans and on site testing
- Commissioning tests and design validation

4. Case Studies

- Case studies on any of the above topics

B. Call for Papers

Papers/Case Studies on topics mentioned above are invited from Utilities, Industrial users, engineering experts, consultants, Turnkey contractors, leading Manufacturers of substation equipment, policy makers etc..

- ➢ The authors should be experts in their field
- ➢ The principal author of paper shall be exempted from the payment of registration fee for Seminar.
- ➢ Intending authors may send the full text of their papers and their brief Bio data, as per the guidelines given below. The last date for the receipt of full text of the paper is 31-08-2014. The papers received will be reviewed by a special committee for the acceptance or otherwise.
- ➢ The Authors whose papers are accepted for presentation/seminar proceedings will be informed by 15-09-2014. A condition of acceptance of paper will be that the author or one of the authors (in the case of multiple authors) will attend the seminar and make the presentation for interaction with the participants.
- ➢ The paper shall contain:

- A descriptive, but brief title.
- Title, name (s) and affiliation of the author(s).
- Address for correspondence (including e-mail address and contact number).
- Description of the objective, methods, results and conclusion, to enable a correct appraisal of the suitability of the proposed paper for the seminar.
- Paper shall be submitted in IEEE format only and details can be downloaded from website: www.spevadodara.in

D. Dates & Venue

The seminar will be held on 10th & 11th Oct. 2014 at the "Appuson Banquet" Opp: RC Patel Estate, Akota, Vadodara, Tel. : 0265-6454545, 9879226000. The venue is on the west side of railway track at a distance of 3 kM from Vadodara Railway station and about 10kM from the Vadodara Airport.

E. Tentative Programme

Friday 10th Oct 2014

08.00 Hrs.	Registration
09.00 Hrs.	Inauguration
10.00 Hrs.	High Tea
10.30 Hrs.	Tech. Session - I
13.00 Hrs.	Lunch
14.00 Hrs.	Tech. Session - II
15.30 Hrs.	Tea
15.45 Hrs.	Tech. Session - III

Saturday 11th Oct 2014

08.30 Hrs.	Tea & Breakfast
09.00 Hrs.	Tech. Session - IV
11.00 Hrs.	Tea
11.30 Hrs.	Tech. Session V
13.00 Hrs.	Lunch
14.00 Hrs.	Tech. Session VI
15.30 Hrs.	Tea
15.45 Hrs.	Tech. Session VII & Conclusion

Kindly visit our website : **www.spevadodara.in** for updates of the programme.

F. Registration

1. Registration Process

The prospective participants, desirous of attending the seminar may register themselves either on line through the web site **www.spevadodara.in** or by sending the duly filled registration form downloaded from the said web site, to the Society of Power Engineers (India), Vadodara Chapter, FF-48, Avishkar Complex, Old Padra Road, Vadodara 390 007 along with registration fee mentioned below.

2. Registration fee

a. Fee per delegate -Rs. 3,000

b. Fee for post graduate students and college teachers (registering in personal capacity) Rs.1,500/-.

c. Fee for under graduate students Rs. 1,000/-.

d. Fee for SPE members (Registering in personal capacity with a valid membership as on 30-06-2014) Rs. 750/-.

e. One of the Authors or the Principal Author will be registered free of charge.

f. The registration fee includes registration kit, one copy of proceedings, working lunch and tea in between the sessions. The delegates shall have to make their own arrangements for boarding, lodging and transport. Spot registration facilities to a limited extent will be available. However, advance intimation in this regard will be appreciated. Registration Fee once paid will not be refunded normally. In exceptional cases, if a registrant is unable to attend the event and claims refund by prior intimation of one week of the scheduled date, fee will be refunded after deducting an administrative charges of 25%. After this date, no request for refund will be entertained. Alternatively, the registered delegate may depute a proxy with prior information to the organization.

G. Payment and correspondence

Suggested Payment Mode

Payments could be made in any of the below mentioned ways as comfortable by you.

1. Sending a crossed cheque drawn in favour of The Society of Power Engineers (I) to our office address mentioned below OR
2. Transferring the amount via Net banking to our bank account as per bank details mentioned below OR
3. By directly depositing the cheque drawn in favour of The Society of Power Engineers (I) in any branch of our bank & intimate us the same.

Account Name: **The Society of Power Engineers (I)**

Bank Name: **Bank of India, Branch – Alkapuri, Vadodara 390 007, Gujarat.**

Saving Bank Account No.: **250110100026520, IFSC: BKID0002501**

H. Sponsorship opportunities

The Seminar provides an effective opportunity for companies to promote their products / services to a focused audience, besides networking with utility engineers during tea/coffee and lunch interval. Sponsors are assured of full visibility with printing of their names on proceedings, banners and other publicity material related to Seminar and will have the privilege of distribution of their products pamphlets / catalogues during the Seminar. Sponsors will also have the privilege of sending delegates who will be exempted from payment of registration fee as indicated here under:

Category	Fee in Rs.	Free Delegates	Free Advertisement for the Special Souvenir
Platinum/Golden Sponsor	1,00,000	7	Full page
Sponsor	50,000	5	Full page
Co-sponsor	20,000	3	Half page
Supporter	10,000	1	Half page

I. Advertisement

Organization can also sponsor for only advertisement in the proceeding published by SPE (I) Vadodara.

Rates for advertisement are as under.

Full Page - Rs. 7,500/-

Half Page - Rs. 5,000/-

J. Product Display

If any individual or an organization wishes to demonstrate/display its products or research work, limited space is earmarked. The Prospective individual or an organization can send their request on or before 30th Sept. 2014. The rates for 2M x 2M will be Rs. 20,000/- for two days, registration of 2- Delegates is included in above charges.

K. Official Language

The official language of the seminar is English.

L. Address for correspondence & Contact Persons.

The Society of Power Engineers (I), Vadodara Chapter,

FF-48, Avishkar Complex, Old Padra Road, Vadodara 390 007, Phone No. 0265-232 2355

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Fundamentals of Power System Protection

PM Shah
Retd. Chief Engineer (Gen), GEB

Introduction of Power System

The electricity generators of Power Houses are connected to EHV switchyard through step up Generator Transformers. The EHV switchyards at Power Houses are connected to EHV lines. The EHV lines are terminated at EHV Transmission substations in different regions. The EHV substations are interconnected to each other within the state and with neighboring states via EHV Transmission lines. The EHV voltages are step down at EHV substations for feeding distribution substations. The distribution substations are mainly radial and feeding electricity via distribution HV and LV lines and Transformers to customers in the District Area. Thus electricity is generated at low voltage level in the Power Houses. Then it is stepped up to EHV voltage level for evacuation and transmission to region and again stepped down to low voltage level to feed distribution District Area to serve the customers. This whole is known as Power System or Power Network or Power Grid

Power System Operation Basic Functions:

1. Economic Load Dispatch
2. Commercial Aspects and metering energy and Tariff
3. Load Generation Balance - Steady state Operation of power system
4. Safe, quick and speedy isolation of fault creating transient disturbance in power system - **A role of relay protection system.**
5. Managing Disaster situations in power system.

A Role of Relay protection systems:

The power should reach to customers at proper voltage and frequency in a safe and secure manner vis-à-vis Power system should not jeopardize / collapse due to abnormal conditions, situations, faults creating transient disturbance.

It is, therefore, utmost necessity to have reliable, accurate, selective, speedy relays and protection systems so that faulty equipment or lines should quickly isolated maintaining the rest of power system in service.

Also relays and protection system should be secure and robust so that unwanted tripping should not occur i.e. mal operation which results in unnecessary outages of lines / equipment from service.

Major elements to be protected individually and as a part of power system as a whole.

a. **Generators**
b. **Transformers**
c. **Reactors**
d. **Bus Bars**
e. **Stuck Breakers**
f. **EHV lines**
g. **HV & LV distribution lines**
h. **Capacitor Banks**
i. **Motors**
j. **Cables**

Lessons learned from global black outs and large disturbances

(I) Power system overview

The growth and extension of AC systems and consequently the introduction of higher voltage levels have been driven by a fast growth of power demand over decades. Power systems have been extended by applying interconnections to the neighboring systems in order to achieve technical and economical advantages. Regional systems have been extended to national grids and later may be interconnected with the neighboring countries. Large systems may come into existence, covering parts of or even whole neighboring countries to gain the well known advantages, e.g. the possibility to use larger and more economical power plants, reduction in reserve capacity in the systems, utilization of the most of the efficient energy reserves as well as to achieve an increase in reliability in the systems.

In future, in the course of deregulation and privatization, the loading of existing power systems will strongly increase leading to bottlenecks and reliability problems. Large blackouts confirmed clearly that the electrical coupling of the neighboring system might also include the risk of uncontrollable cascading effects in large and heavily loaded interconnected power systems. Hence for avoiding cascading leading to blackouts, avoidance of loop flows, prevention of voltage collapse, elimination of stability problems, the implementation of advanced technology in transmission systems is necessary. That is HVDC Technology and FACTS (Flexible AC Transmission Systems) Technology.

(II) Some Type Of Transient Disturbances

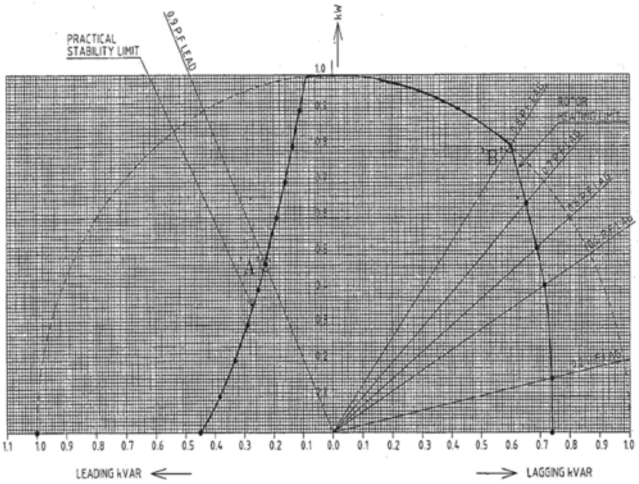
1. At steady state operation of power system, the generation is equal to load, i.e. frequency of system is equal to 50 Hz. When the frequency goes below 50 Hz, the load is more than generation and, when the frequency goes above 50 Hz, the load is less than generation. The small incremental changes are taken care of by the turbine electro hydro governor at generating plants or load shedding by definite time under frequency relays at different locations. Thereby steady state operation of the system is maintained.

   But when there is sudden loss of generation due to tripping of large unit or number of units, then frequency would suddenly drop to very low level and the fast load shedding is required to maintain the load generation balance in the system. The protection system using Under Frequency Relays with df/dt feature are provided at different locations in District and Region's radial distribution substations to give instant load relief.

2. The de-linking of trunk substation due to bus fault in it creates disturbance in the power system. The portion of system having number of generators but no load centres, the frequency would suddenly go up and units would trip on over frequency protection of units. And the portion of system having more load centres and less generating units would experience the very low frequency and units would trip on under frequency protection of units. To minimize this type of disturbances, the substation is provided with double bus arrangement. The generating unit bays and load line bays are equally distributed on each bus. Bus Bar and Stuck Breaker protections are provided so that the faulty bus or stuck breaker bus will be isolated quickly and healthy bus and bays will remain in service maintaining the power system intact.

3. When transmission lines between two major substations trip due to fault, the generation flow to major load centre is perturbed. The generation would flow to the load centre by available other route. If this route has higher impedance than the original route then power flow would oscillate as generation is intact and load also intact. The generators try to get new equilibrium but may get or may not and they might swing around the synchronous speed. This results in Power Swing phenomena in power system. In power swing conditions, the load impedances may enter into distance protection relay characteristics, which would mal-operate the distance relay. Therefore, power swing blocking feature is required in distance relay. It may block the distance relay about few seconds. Then again releases the relay for operation. By the time swing may recover and if not then distance relay element operates and extends trip to the breaker.

Know behavior of Generator, Transformer and Lines in Power System Generator



Power Capability Diagram of Generator

1. **Synchronous Generator Mode**

   When steam input in turbine is there and DC field is there, synchronous machine delivers the electrical power through generator transformer to power system. This is normal operation of synchronous generator.

2. **Synchronous Motor Mode**

   When steam input valve is closed due to trouble on turbine side or boiler side, there is no steam input in turbine but the DC field is intact then the machine will take power from power system and run as synchronous motor. In this case the turbine is rotating with air in casing. This is known as air churning of turbine. To disconnect the generator from power system reverse power or low forward power protection is provided. This operation could be tolerated for some minutes.

3. **Asynchronous (Induction) Generator Mode**

   When steam input in turbine is there but DC field is not there due to trouble in DC excitation system then the machine will run as Asynchronous (Induction) Generator taking reactive power from the system to maintain the excitation. This operation should not be allowed more than few minutes. For protection against this contingency, the field failure protection is provided which first trips the turbine and then the generator breaker on reverse power protection to disconnect the generator from power system.

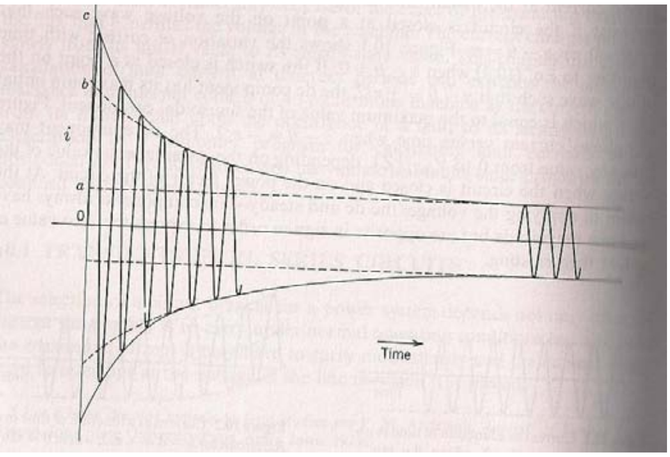
4. **Asynchronous (Induction) Motor Mode**

   When there is no steam input in turbine and no DC field in rotor then the machine will run as an induction motor. This will draw active and reactive power from system. This will results in heating of rotor. This operation is much more detrimental to machine. The machine should be removed immediately from bar. This is effected by field failure protection and reverse power protection provided to generator.

5. **Single Phase Motoring of Generator**

   When generator transformer breaker's one or two poles do not open, then in that case single phase motoring occurs. This creates negative sequence unbalanced current in generator. The flux produced by it rotates in air gap with the double frequency. This will heat the rotor heavily. To avoid this situation, normally gang operated generator breaker is provided which will trip all the 3 poles or in case of trouble in breaker itself, all the 3 poles will not trip. This situation is taken care of by stuck breaker protection, which will disconnect all the breakers on the bus bar to which this machine is connected.

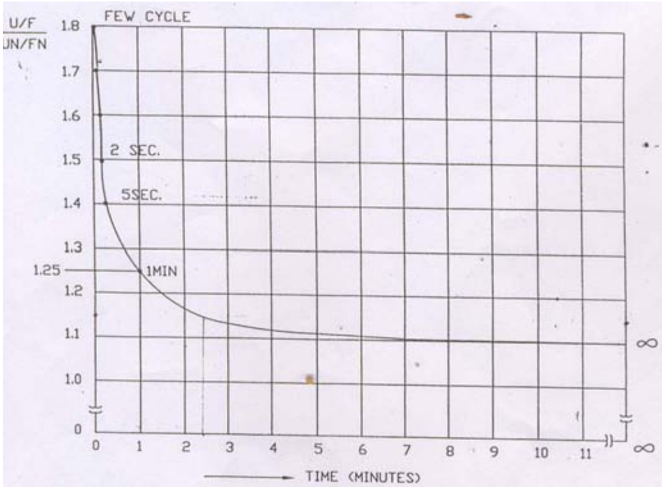
6. **Symmetrical short circuit behavior of generator**



Symmetrical short circuit behavior of generator

This initial short circuit current is gradually decreasing with time as shown in figure from sub-transient to transient and transient to steady state values after inception of 3-phase fault on generator terminals due to armature reaction of rotating machine. The steady state current is some time might be less than the full load value. As such the voltage controlled or restrained O/C Relays are used for generator short circuit protection instead of simple non directional overcurrent relays.

Transformer



Transformer over fluxing curve

1. **Over Fluxing of Generator Transformer**

   While taking the generator on bar, first rated speed of turbine is achieved and then excitation is made on for building of generator voltage keeping GT breaker in off condition before synchronizing the machine with system. In this situation for any reason turbine trips and DC field breaker does not trip, then turbine speed is costing down and as a result frequency of generator voltage goes on decreasing. This results into over fluxing of generator transformer. The ratio V/F is increasing which is harmful to it. That is transformer no longer work as inductive coils developing back emf and work as resistors creating short circuit and flowing heavy magnetizing current damages the transformer.

2. **Transformer Magnetizing Inrush Current**

   The transformer charging inrush current is about 3 to 4 times its full load value and contains the following harmonics.

Harmonic Component	% of Fundamental
Fundamental	100
2nd	63
3rd	27
4th	5
5th	4

The transformer stabilization takes few seconds. As such the differential relay might mal-operate during charging of transformer. The modern Static and Numerical Differential relays are provided with harmonic restraint so that transformer would not unnecessary trip during charging unless there is fault in the transformer.

Attributes to Relay Protection Systems.

- **What is Fault ?**

  A fault is an abnormal state of the power system mostly short circuit due to failure of electrical equipment/line.

  A power system state is healthy when all three phases are balanced symmetrical.

  When a fault occurs the symmetry of a balanced three phase network is upset resulting in an unbalance current and voltage appearing in the system. This is an unhealthy state of power system.

- **Types of Faults:**

  A. Symmetrical Faults: When fault involves three phases equally at the same location, creates a symmetrical fault.

  B. Asymmetrical Faults: Single phase to ground, phase to phase and double phase to ground are asymmetrical faults.

- **A fault might occurs due to :**

  a. Lightening and switching surges

  b. Ageing of insulation of electrical equipment

  c. Overloading of electrical equipment

  d. Withstanding number of short circuits shocks when fault occurs on lines

  e. Flash over of insulators due to wet and/or contaminated atmosphere.

  f. Conductor or earth wire broken and falling on other conductor, tower structure.

  g. Tree touching to conductor of line.

- **What Relay protection system does?**

  An immediate step is to be taken to remove the fault from a power system as quickly as possible. This removal process executed automatically i.e. without human intervention. The devices and associated equipment, instruments that do this job are collectively known as Relay protection system.

- **Relay protection system consists of :**

  a. Circuit Breaker - to open contacts for isolation of faulty section.

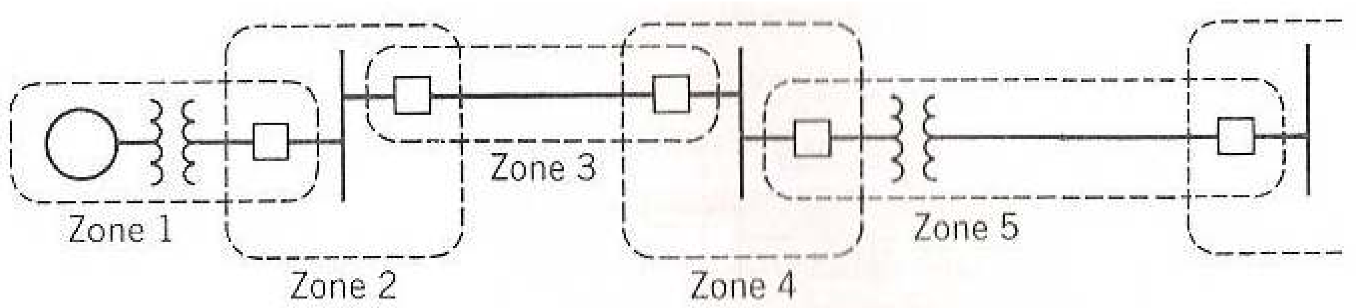
  b. Current and Voltage Transformers - to provide signals to relays

  c. Relays - a decision making devices.

  d. DC batteries - to provide independent source to trip coils of breaker and Relay panel.

- **Zones of protection**

Every inch of power system to be protected against the fault that might occur in it. That is no portion howsoever small to be left out without protection.



ZONE-1 – GENERATOR & TRANSFORMER
ZONE-2 – BUS BAR WITH BREAKERS
ZONE-3 – EHV LINES
ZONE-4 – BUS BAR WITH BREAKERS
ZONE-5 – TRANSFORMER AND EHV LINE

- **Main Protection**

  Main protection is unit type which takes care between the boundaries defined by current transformers locations. For example generator high impedance relay transformer biased differential relay, restricted E/F relay, bus-bar differential relay, carrier aided distance protection relay. These protections are instantaneous and not required time grading coordination.

- **Backup Protection**

  Backup protection is non directional O/C and E/F, directional over current and Earth fault relays, Zone-2, Zone-3 of distance protection relay. These protections are required time grading. It is to act when primary main protection fails to act or the protection of faulty section fails to operate for fault in its own section.

➢ **Duplicated Main Protection**

Main protections are duplicated right from current transformer cores to relay protection system and trip coils of breakers including DC sources for EHV lines, generators and transformers. That is main-1 and main-2 or main and standby protections.

➢ **Type of Relays**

(i) Magnitude Relays

a. Over current / undercurrent Relays
b. Over voltage / under voltage Relays
c. Overpower / under power Relays

(ii) Direction Relays

a. Directional over current Relays
b. Directional Earth fault Relays

(iii) Ratio Relays

a. Non directional impedance relays
b. Directional impedance relays - Mho Relays
c. Over flux V/F Relays

(iv) Differential Relays

a. High impedance differential Relays
b. Biased differential Relays

(v) Pilot Relays

a. Direction comparison Relays
b. Phase angle comparison Relays

(vi) Frequency Relays

a. Plain frequency Relays
b. df/dt Relays

List of Protections for Power System Elements

1. Protections of Generators

i. High Impedance Differential Relay for Generator Windings.
ii. Biased Overall Differential Relay for generator and Generator Transformer.
iii. Stator E/F Relay.
iv. Field Failure Relay.
v. Pole Slip Relay.
vi. Back Up Impedance Relay.
vii. Voltage controlled or Restrained Over current Relays.
viii. Under Frequency / Over Frequency Relays.
ix. Over Voltage / Under Voltage Relays.
x. Generator Transformer Over Flux Relay.
xi. Inadvertent Energising Protection for Generator.
xii. Generator Transformer Biased Differential Relay.
xiii. Rotor E/F Relay.
xiv. Negative Sequence Relay.
xv. Breaker Failure Relay.
xvi. Reverse and Forward Power Relays.

2. Protection of Transformers and Reactors.

i. Biased Differential Relay.
ii. REF Relay.
iii. Back up Non-Directional Over current and E/F Relays.
iv. Back up Impedance Relay for Reactor.

3. Protection of EHV Transmission Lines.

i. Distance Relays.
ii. Back up Directional Overcurrent and E/F Relays.
iii. Pilot Relays.
  a. Phase Comparison Relays.
  b. Directional Comparison Relays.

4. Bus Bar And Stuck Breakers Protection

Current transformers and voltage transformers

The magnitude of current and voltage in power circuits are too high which cannot be handled by the secondary instruments like relays and meters. Hence instruments transformers are used to scale down replica of the primary quantities within the required accuracy for connecting relays and meters on its secondary side of instrument transformers.

A. Current Transformers classification

1. Metering class CTs

Example - Class 0.2, VA burden 15, ISF 5
It is to be accurate over a range of 5% to 125% of nominal current.
It is to saturate at less than 5 times nominal current so that the meters not damaged.

2. Protection class CTs

Example: 5P 20, 30 VA

It is to be accurate for 20 times nominal current at the connected rated burden.

3. PS class CTS

Example: Ratio 100/1 A
Vk >= 100 Volts
Im <= 30 mA at Vk/2
Rct <= 1.0 ?

4. Core balance CTs

CBCTS are used for sensitive earth fault protections where the required sensitivity cannot be obtained using CTs residual connection or by using CT on neutral earth connection.

B. Voltage Transformers classification

(i) Metering VTS Example: 0.2/0.5class, burden 50 VA

(ii) Protection VTS Example: 3P class, burden 100 VA

(iii) Residual VTS Example: 5 PR class, burden 50 VA

Type of VT connections

a. V-V

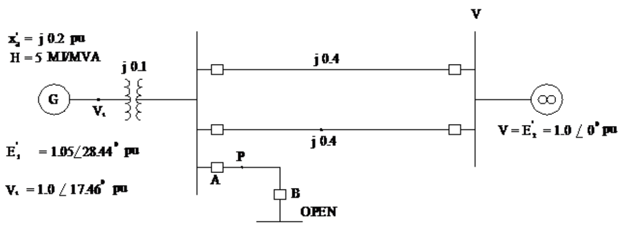
b. Star/star

c. IVT connection for star / open delta

Managing Disaster situations in Power System

1. Slow Decay in frequency - Automatic load Shedding by plain under Frequency Relays.
2. Fast Decay in frequency - Automatic load Shedding by - df/dt Relays.
3. Islanding of Small power plants on their own house load or radial load by -P + (-df/dt) in case of cascade tripping may result in Blackout.
4. Restoration approaches to rebuild the grid.
5. Survival power by DG Sets, Mini Hydro sets
6. Startup power for Auxiliaries of Units.
7. Re-synchronization of Islanded power system pockets to rebuild the main power system

Transmission Lines System



The transient disturbances are:

- Transmission system faults
- Loss of generating units
- Sudden severe load changes
- Long line switching operations

In such disturbances the power system should remain stable. That is the speed of rotors of generators temporarily departed from synchronous speed (constant speed) should return to synchronous speed after clearance of fault. The electro mechanical balance is again achieved. This is known as Transient stability of power system. The generator output Pe to change rapidly whereas the mechanical input power Pm from the prime mover remained constant. Since the Pm is steady, the electrical output power Pe will determine whether rotor accelerates decelerates or remains at Steady state synchronous speed. The rotor acceleration or deceleration increases or decreases rotor angle δ from steady state synchronously rotating reference axis. That rotor angle δ is swinging with reference to either infinite bus or other machine of power system.

1. **Basic Swing Equation for Rotor**

$$\frac{2H}{\omega_s} * \frac{d^2\delta}{dt^2} = Pa = Pm - Pe \quad pu$$

where

H = Inertia constant MJ/MVA

ω_s = Synchronous speed

δ = Machine Rotor angle with respect to infinite bus or other machine

t = Time in seconds

Pa = Accelerating power positive or negative

Pm = Mechanical input power which is constant

Pe = Electrical output power which determines whether rotor accelerates or decelerates or remains at synchronous speed.

2. **Power Angle Equation for Transmission Lines**

$$Pe = \frac{|E'_1| * |E'_2|}{X} * \sin\delta$$

Where X is the transfer reactance between generator and infinite bus or other machine internal voltages

3. **Critical clearing time of fault by Equal Area Criteria**

Whatever kinetic energy is added to the rotor following a fault must be removed after fault is cleared to restore the rotor to the synchronous speed. The shaded area A_1 is dependent upon the time taken to clear the fault. If there is delay in clearing the fault, δ_c is increased; likewise the area A_1 increases and the Equal Area Criterion requires that area A_2 to also increase to restore the rotor to synchronous speed at a larger angle δ. If the delay in clearing the fault is prolonged so that the rotor angle δ swings beyond the angle δL, then the rotor speed at that point on the power angle curve is above synchronous speed when positive accelerating power is again encountered. Under the influence of this positive accelerating power the angle δ will increase without limit and instability of machine results. Therefore, there is a critical angle for clearing the fault in order to satisfy the requirements of Equal Area Criterion for stability. This angle is called the critical clearing angle δcr. The corresponding critical time for clearing the fault is called the critical clearing time tcr.

By Equal Area Criterion, critical clearing angle δcr and time tcr are obtained by following formulae:

(i) $\delta_{cr} = \text{Cos}^{-1} [(\pi - 2\delta_0) \text{Sin}\delta_0 - \text{Cos}\delta_0]$

(ii) $t_{cr} = \sqrt{\dfrac{4H * (\delta_{cr} - \delta_0)}{\omega_s Pm}}$

Example: For given transmission system:

When Pe = Pm, the machine operates at Steady State Synchronism Speed

$$Pe = \frac{|1.05| * |1.0| * \text{Sin}\delta}{0.5} = 2.1\text{Sin}\delta = Pm$$

$$= 1.0 \text{ pu}$$

$$\delta_0 = \text{Sin}^{-1} \frac{1.0}{2.1} = 28.44^0 = 0.496 \text{ rad}$$

b. $\delta_{cr} = \text{Cos}^{-1} [(\pi - 2 \times 0.496)\text{Sin}28.44^0 - \text{Cos}28.44^0]$

$= 81.697^0 = 1.426$ rad

c. $t_{cr} = \sqrt{\dfrac{4 \times 5}{314 \times 1.0} *(1.426-0.496)} = 0.244$ sec

4. Rewritten swing Equation for Rotor :

For fixed mechanical input power Pm the small incremental changes in electrical output power and power angle at the steady state operating point are

$$\delta = \delta_0 + \delta_\Delta, \quad p_e = p_{e0} + p_{e\Delta}$$

The swing equation governing incremental rotor angle variations is rewritten as under.

$$\frac{d^2\delta_\Delta}{dt^2} + \frac{\omega_s . s_p}{2H}\delta_\Delta = 0$$

This is linear second order differential equation. When Sp is positive on the power curve, the solution $\delta_\Delta(t)$ corresponds to simple harmonic oscillations of an undamped swinging. When Sp is negative on the power curve, the solution $\delta_\Delta(t)$ increases exponentially without limit. The operating point $\delta_0 = 28.44^0$ is a point of stable equilibrium that is rotor angle swing is bounded by the various damping influences caused by prime mover, system loads and machine itself following a small perturbation. On the other hand the operating point $\delta_{max} = 151.56^0$ is a point of unstable equilibrium since Sp is negative at this point on power curve. That is not valid operating point.

d. $\delta_{max} = \pi - \delta_0 = 180^0 - 28.44^0 = 151.56^0$

e. Synchronising power coefficient

$S_P = P_{max} \text{ Cos } \delta_0 = 2.1 \text{ Cos } 28.44^0 = 1.8466$

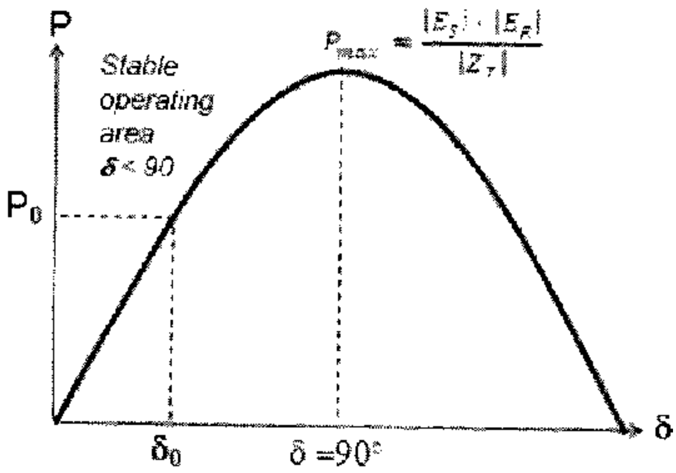
f. Angular frequency of oscillation $\omega_n = \sqrt{\dfrac{\omega_s \times S_P}{2H}}$

$= \sqrt{\dfrac{314.2 \times 1.8466}{2 \times 5}} = 7.62$ elec rad/sec

g. Frequency of oscillation $f_n = 7.62/2\pi = 1.21$ Hz

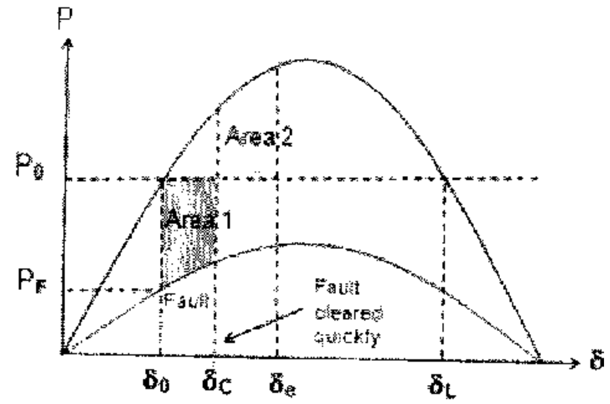
h. Period of oscillation T = 1/1.21 = 0.8265 Sec

This example serves to establish the concept of critical clearing time which is essential to design of proper relay protection scheme for faster clearing faults in system. This is just simplified example. For large system with number of machines, the critical time could be estimated by solving swing equation and power angle equation with digital computers.

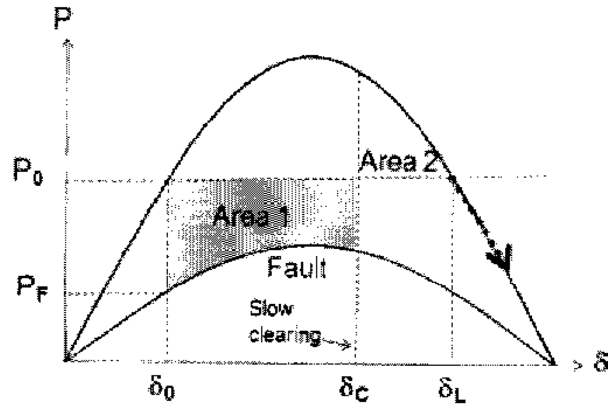


The power angle curve shown in Fig. graphically describes the power relationship between the power transmitted and the angle between the two ends. It shows that the power transfer increases with increasing angle δ from 00 to 90^0 and then decreases beyond 90^0.

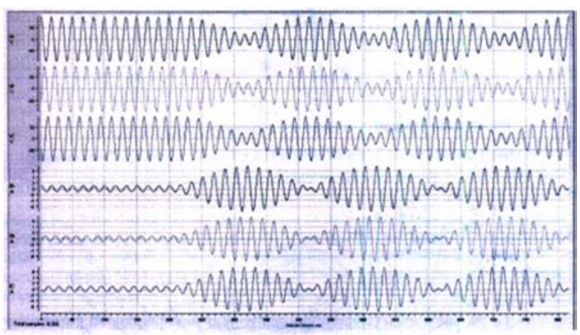
Systems are normally operated well below maximum power transfer at 90^0, the maximum power transfer angle at some power Po corresponding to an angle δ_0.



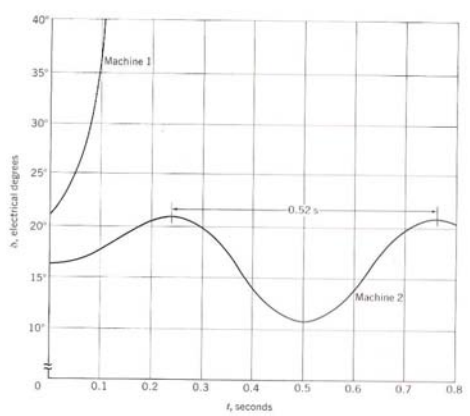
Fast Fault clearance and Stable System



Slow Fault clearance and Unstable System



Voltage and Current Waveforms at Bus S during Swinging of System



Swing curves for machines 1 and 2 for clearing fault at 0.225 s. (for Illustration)

- **What is effect of delayed clearing of fault?**

  If a fault persists for an extended period, the following undesirable effects are likely to occur:-

  a. Reduced transient stability margins for power system.

  b. Damage to electrical equipment that are feeding fault due to heavy short circuit currents, unbalanced currents flowing through it.

  c. Explosion might occur in equipment containing insulating oil during a short circuit which might also cause fire hazards.

  d. Cascade trippings by a successive protective actions taken by different protective relays in the system.

Factors increasing critical clearing time of faults

1. Excitation systems

When a fault occurs on a system the voltages at all buses are reduced. At generator terminals, the reduced voltages sensed by the AVR act to restore the generator terminal voltages. The boosting the voltage to the field winding of the generator is increased air gap flux which creates a restrain torque on rotor which tends to slowdown initial rotor angle swing following fault. Modern excitations system rapidly responds to bus voltage reduction and can effect from 10 ms to 30 ms gain in critical clearing time for faults on the high side of the generator step up transformer.

2. Turbine valve governor control

Modern electro hydraulic turbine governing system has ability to close turbine valve to reduce unit acceleration during severe system faults near the unit. Immediately upon detecting differences between mechanical input and electrical output, control action initiates the valve closing which reduces the power input. A gain of 20ms to 40ms in critical clearing time can be achieved.

3. Single pole operation of circuit breakers controlling EHV transmission lines.

Since single phase faults occur more often than three phase faults, relaying schemes, allowing independent or selective circuit breaker pole operation, can be used to clear the faulted phase while keeping the un-faulted phases intact. The gain in the critical clearing time by 40 ms to 100 ms is achieved.

Measures to increase Transient Stability of Power System

1. **HVDC back to back connection between regional power system for better stability.**

2. **Series Capacitor Compensated EHV Long Lines.**

   Reducing the reactance of a long EHV transmission line by using series capacitors which will increase the maximum power transferred during system fault conditions.

3. **Multiple Parallel Lines (Two or More).**

   Increasing the number of parallel lines between two points to reduce the reactance for maximum power transferred during system fault conditions unless the fault occurs at a paralleling bus.

   In short increased power transferred during a fault means lower accelerating power for the machine and increased chance of electro-mechanical balance for stability of machine.

4. **Bus to Bus connection**

   Bus to Bus connection means there should be two or more different paths of transmission lines at one voltage level between generating points and major load centers without transformer in between.

5. **Interconnectors**

   Interconnectors between substations of two or more different paths of power flow in order to provide other path for generation to flow to system in event of failure of one path.

6. **Numerical Relays**

   Faster fault clearing time by using modern Static and Numerical Relays to clear faults and abnormal conditions

Summary:

The power system should remain stable in transient disturbances created by Transmission System faults, Loss of generating units, Sudden Sever load changes, Long Line Switching operations etc. This transient stability of system is achieved by fast clearance of faults and abnormal conditions by Relays and protection schemes provided to Generators, Transformers, EHV Lines, Bus-bars and Automatic Load Shedding on Under Frequency Relays.

The slow clearance of faults and abnormal conditions would result in Power Swings and Pole Slips creating unstable situation in system. Also successive protective actions taken by different protective relays might result in cascade tripping leading to Blackout in the Region

In the synchronous power system an important parameter to be monitored and controlled is system frequency which is common one for entire system. This parameter is 50Hz and to be maintained in the band of 49.5Hz and 50.5Hz. Whereas fouling abnormal conditions and transient disturbances encountered in the entire system are much more and of different types and at different locations at every occasion in real time operation of the system. This might disturb the common parameter frequency either to become low or high in the entire system or in one part of system very low and in other parts of system very high during split of system due to heavy disturbance.

In view of this, it is now to think that the regional synchronous power systems to be interconnected by HVDC links (asynchronous back to back connection) between regions. This will allow transfer of active power in either of regions to maintain their frequency. The reactive power requirement of the regions is to be compensated by installing HV capacitors in their regions. Every region would have its own frequency and if it is perturbed then that region would be affected and not all other regions of entire power system.

Biography:

Er. PM Shah graduated in Electrical Engineering MS University, Baroda in 1964.

He joined GEB in 1964 as Deputy Engineer (O&M) and retired as Chief Engineer (Gen) in 1999. During his service in GEB, he had worked for Testing & Commissioning of Protection Systems up to 210MW units at Thermal & Hydro Power Stations. He had also earned a credit for maiden commissioning and synchronizing of 12 Generating Units of different Power Stations in Gujarat. He had also worked for Testing & Commissioning of Protection Systems for 400kV & 220kV EHV Lines and Power Transformers up to 500MVA. After retirement, he had supervised electrical commissioning work including synchronizing of 2 x 125MW units of GMDC at Akrimota as Electrical Representative of M/s Desein Consultant Ltd. He continues to render his services as a free lance Testing & Protection Consultant.

He is considered to be a God Father of Power Protection System in Gujarat.

Random Thoughts

- N. Dinker

Requirements and linkages of Members of SPE and their responsibility as parents.

SPE(I), under its canopy, has Members of a large spectra of age-groups ranging from teenagers (Student-Members) to those touching eighties and nineties (Life Members). The needs and requirements of these Members, whether it is in technical matters or other social activities, naturally are different. The technical needs are taken care of fairly well by SPE by way of seminars, technical visits, Tech Talk and discussions in a well organized manner, frequently, for all classes of its Members.

Many of the members of SPE are already holding the status of parenthood and many more will join them sooner or later. The purpose of this write up is as to how our Members, can, not only be technical experts, but also how they can become a good parent.

What the psychologists have to say is presented in brief. What is missed by seniors may not be repeated by new generation, by having proper approach in their dealings with their children.

“A parent is often a child's first introduction to the world. Everyone starts out with one or both, of their parents as his role model. They are nothing short of a God for the little child. When he observes his parents fighting and arguing, it leads to a state of great confusion. Even an infant who cannot understand the words and language, effortlessly interprets the intended meaning from the tone of voice and facial expressions.

When two partners show little or no respect to each other, it wrecks havoc on the mind of the child. This puts a tremendous burden on the child to some how set things right. When two parents cannot act their act together for whatever reason, one of the parents starts to look up to their child for comfort and emotional support.

As a result, the suffering parent clings more to the child. The child is not experienced enough to understand the underlying complexities. Always comforting his mother, he has to play the role of a father, an adult. And this causes an inrepairable damage to a child's understanding of himself, of this world, and of his own in personal relationships in times to come.

Later on, such children may succeed in their careers, they may be accomplished scientists, but their ability to have a functional relationship often remains greatly impaired. Why? Among many other reasons, the primary one is that they try to act as a parent to their partners as well. There will be no equality in such a relationship and it will either fall apart or foul.

A child, whose one parent was more dominating, often ends up, in an unfulfilling relationship in his own life.

Kids between the ages of four and eight often have parents in all their drawings. They cannot imagine a world without their parents. The need for their parents attention, support, love and care is nonnegotiable. Their survival and growth depends on it. The word of their parents is absolute for them.

When children observe their parents lying to others, when they see them living in a certain way, this becomes their truth as well. For a child, it is hard to imaging that their parents are not perfect. Such a realization often comes much later and even when it does, at first, they feel guilty thinking this way, for not believing in their parents or for being ungrateful.

Summarizing, the psychologist, have this much to say that the grown up parents now, who had a difficult childhood, need not take this as their fault. They need not hold themselves responsible, as they were not the reason but the victim. The emerging new parents may try to become 'perfect parent' by shaping a good environment at home for their children. It is aptly said “A lump of clay may be outstanding in its own right, but ultimately, the potter shapes it. Such important is the relationship of a father to his children.

Thought for the day
Ponder Deeply

- Make peace with your past so that it does not spoil your present
- What others thinks of you is none of your business.
- Time heals almost everything; give some time to the time.
- No one is the cause for your happiness except yourself
- Do not compare your life with those of others. You have no idea what their journey is all about.
- Stop thinking too much; it is all right not to know all the answers.

- Smile, you have not lost anything because you do not own anything.

IT MATTERS IN LIFE......

- The plus symbol is made with two minus symbols! So all negative things can be shaped as positives by our smart work and positive thinking.
- Success is the problem but failure is the formula. You can't solve the problem without knowing the formula.
- Anger comes alone but takes away all the good qualities from us. Patience too comes alone but brings all the good qualities to us.
- Instead of thinking about what you are missing, sometimes it is good to think about what you have that many are missing.
- Efforts towards success will make you a master. But efforts towards satisfaction will make you a legend.

Life is like a Piano

Life is like a piano. The white keys represent happiness, the black keys show sadness. But as you go through life's journey, remember that the black keys make music too.

Life is like playing a piano. You need to use all the keys, be it black or white, to make beautiful music. Happiness and sadness, all things in life, will always come in pair and both sides prove beneficial as you go along on your Journey. Happiness provides satisfaction and resolution, sadness on the other hand provides perseverance and strength.

Remember that life is not always the way we want it to be. At times, you are playing a perfect tune but at other times, you are not playing good melodies. There are the times when you have to find the right pitch, the right keys and the right learning. These are life's challenges. Accept them and for sure you will be playing a perfect concert.

The Road to Success

The road to success is not a straight one
There is a curve called failure
A loop called CONFUSION,
Speed bumps called FRIENDS
RED lights called ENEMIES
Caution lights called FAMILY
You will have fiats called JOBS
But if you have a spare called Determination
An engine called PERSEVERANCE
Insurance called FAITH
You will make it to a place called SUCCESS

==

God has given us two gifts,
One is Choice, and the other is Chance.
Choice is to select a good one, and
Chance is to have the best one

↓ CHANCE

CHOICE ↑

List of membership during Quarter

Sr. No.	G.R. No.	Name	Member	Sr. No.	G.R. No.	Name	Member
1	2167	Prajapati Dilip K.	Life Member	10	2176	Talati Atulkumar C.	Life Member
2	2168	Parikh Deep H.	Member	11	2177	Ingle Vipul K.	Member
3	2169	Thakkar Falguni H.	Life Member	12	2178	Panchal Jay D	Associate Member
4	2170	Patel Tushar P.	Student Member	13	2179	Kotwal Kushal R	Associate Member
5	2171	Shah Siddharth M.	Student Member	14	2180	Patel Bharatkumar D.	Member
6	2172	Modi Jaimin D	Student Member	15	2181	Naik Rameshchandra R	Member
7	2173	Prajapati Ankitkumar M.	Associate Member	16	2182	Khatua Kaushik	Associate Member
8	2174	Venkiteswaran Vivek	Associate Member	17	2183	Neha	Associate Member
9	2175	Desai Ishan M.	Associate Member				

Inaugural function of IGS National Workshop on "Geotechnical Considerations for Power Equipment Foundations" on 6th & 7th Jun 2014.
(L to R) Er. SM Takalkar, Dr. AV Shroof - Chairman IGS and Er. VB Harani- Secretary, SPE(I) VC.

Er. SM Takalkar being felicitated during the Workshop for presenting papers.

Er. PA Shah speaks on Small Hydro Power Projects during a lecture programme on 20 June 2014

The audience comprising members & their spouse during a lecture programme by Dr. Bimal Chhajed on 18 May 2014

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To ______________________

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