POWER POINT PRESENTATION

ON

SWITCH GEAR AND PROTECTION

IV B.TECH I SEMESTER(JNTUH-R15)

Prepared
by

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UNIT-I

CIRCUIT BREAKERS

WHAT IS A CIRCUIT BREAKER?

- A circuit breaker is an equipment that breaks a circuit either manually or automatically under all conditions at no load, full load or short circuit.

Operating Principle

Two contacts called electrode remains closed under normal operating conditions. When fault occurs on any part of the system, the trip coil of the circuit breaker get energized and contacts are separated.

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Arc Phenomenon

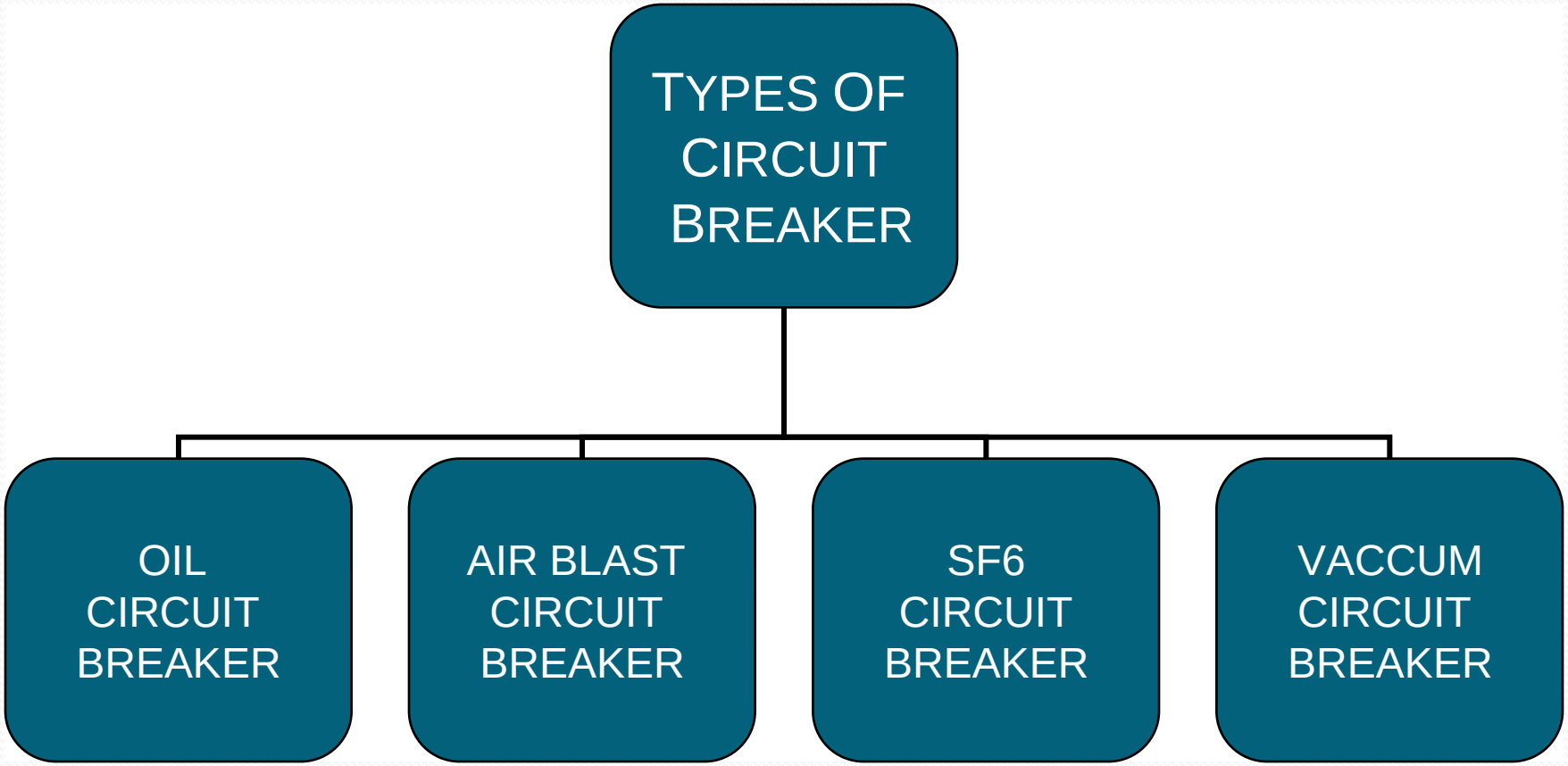
- An arc is struck when contacts are separated. The current is thus able to continue. Thus the main duty of a circuit breaker is to distinguish the arc within the shortest possible time.
- The arc provides the low resistance path to the current and the current in the circuit remains uninterrupted.

- ***The arc resistance depends upon the following factors.***
- Degree of ionization
- Length of the arc
- Cross Section of the arc

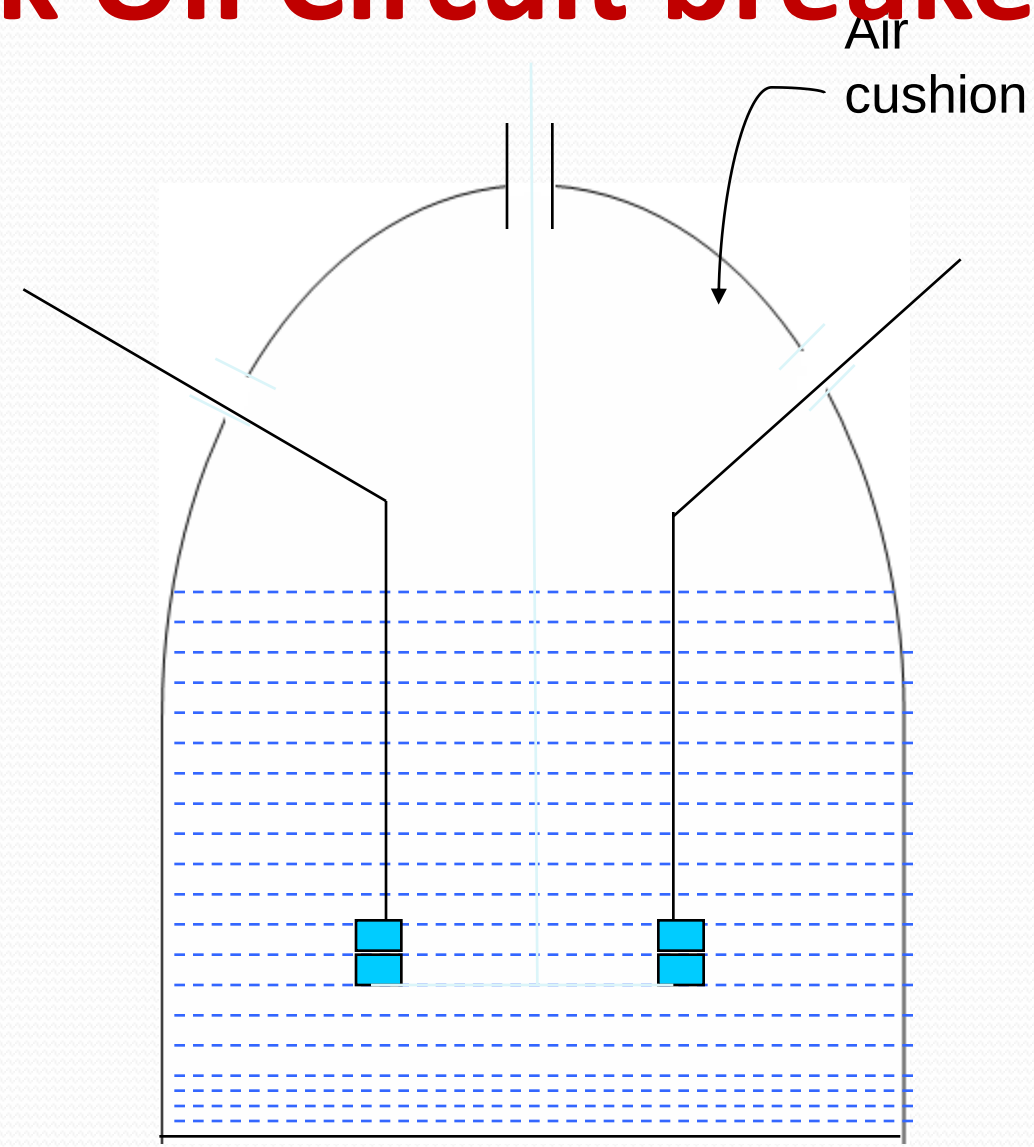
Methods of Arc Extinction

High Resistance Method

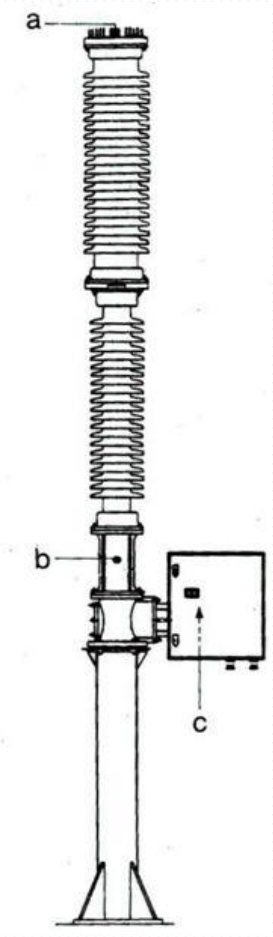
Low Resistance Method


TYPES OF CIRCUIT BREAKER
OIL CIRCUIT BREAKER
AIR BLAST CIRCUIT BREAKER
SF6 CIRCUIT BREAKER
VACCUM CIRCUIT BREAKER

Bulk Oil Circuit breaker



Low Oil Circuit Breaker

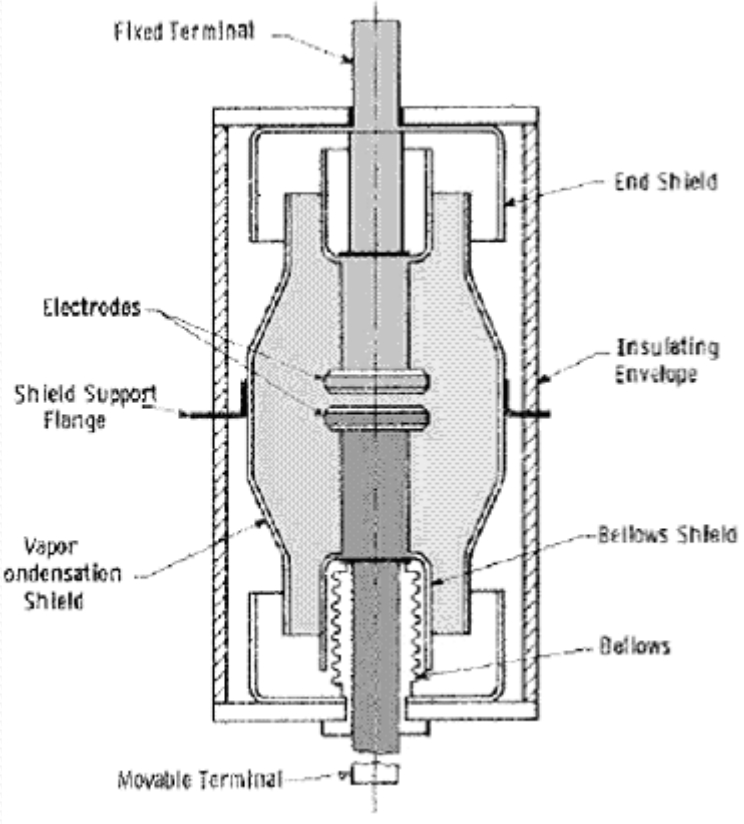


Consists of two parts.

Supporting Chamber.

Circuit-Breaking chamber(consist of fixed and moving contact)

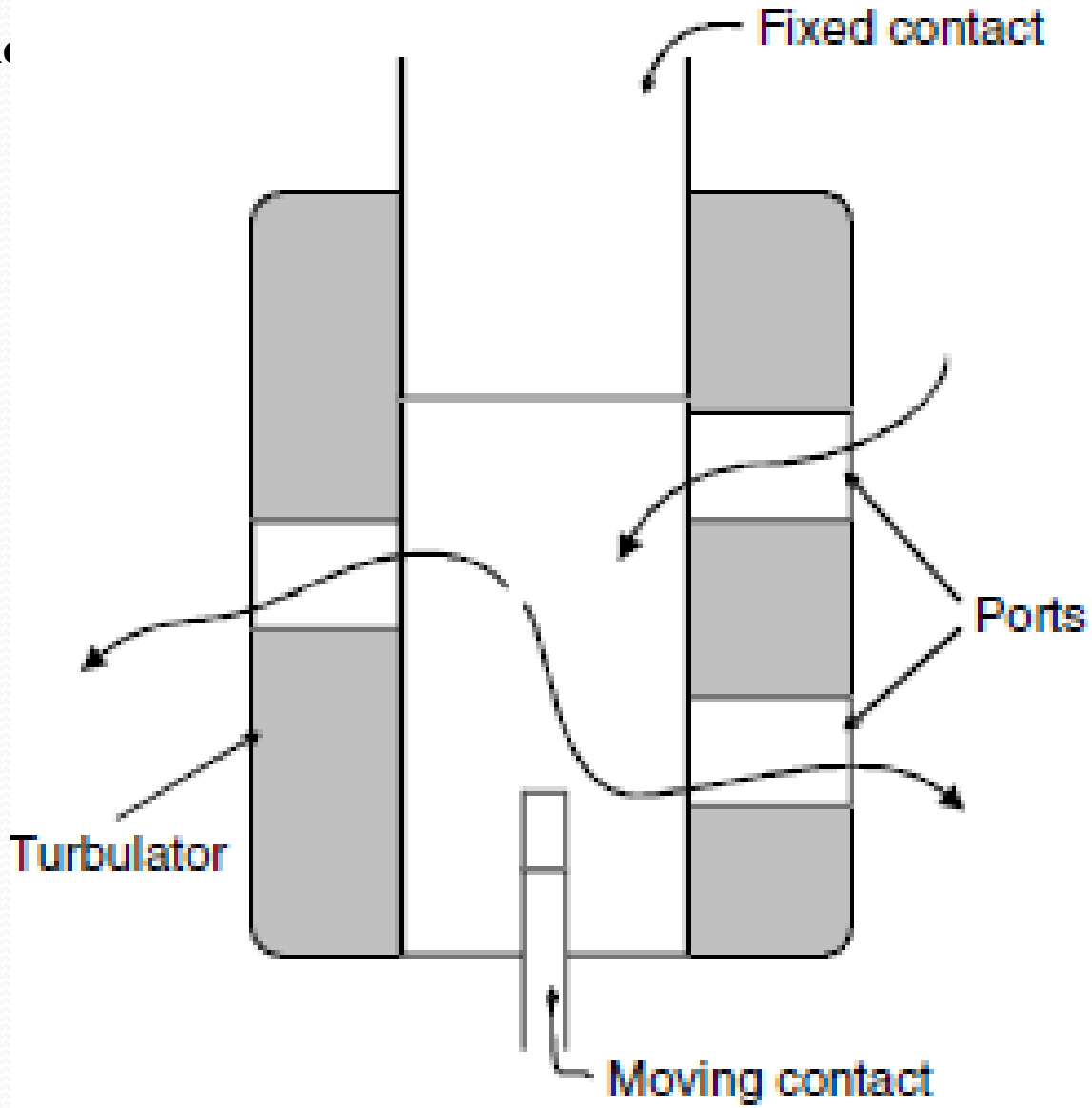
Vacuum Circuit Breaker



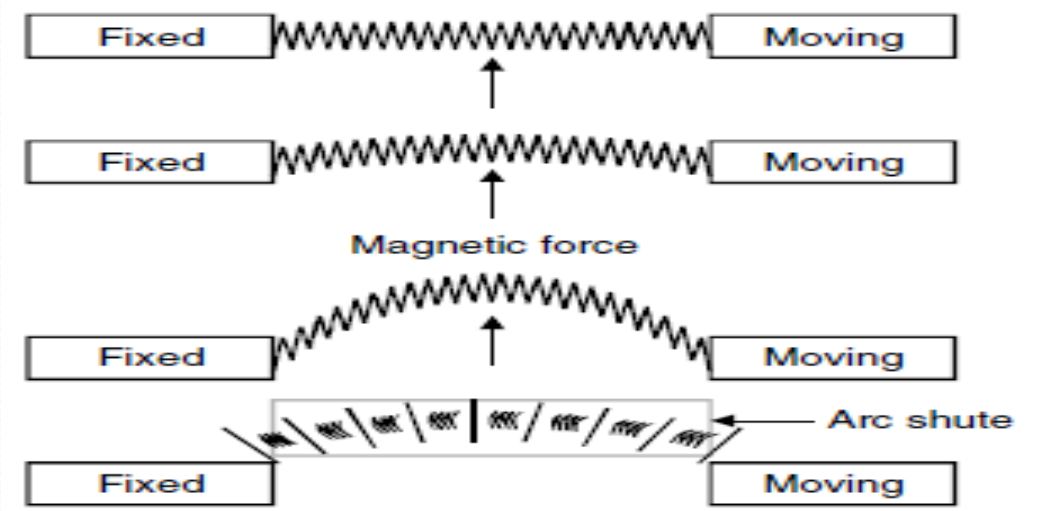
SF6 Circuit Breaker

1. Sulphur Hexafluoride (SF6) gas is used as an arc quenching medium.
2. SF6 is an electro-negative gas.
3. It has strong tendency to absorb electrons.
4. When contact are opened in a high pressure flow of SF6 gas, arc produced.
5. Free electron in the arc are captured by the gas.
6. Which build up enough insulation strength to extinguish arc.
7. it is much effective for high power and high voltages services,

Arc control devi



Air break circuit breaker



•Interrupting contacts situated in air instead of any other artificial medium
•Arc is chopped into a number of small arcs by the Arc-shute as it rises due to heat and magnetic forces.
•The air circuit breakers are normally employed for 380~480 V distribution.
•Suitable for high current interruption at low voltages

Type	Arc Quenching Medium	Voltage Range and Breaking Capacity
Miniature circuit breaker	Air at atmospheric pressure	400-600 V; for small current rating
Air-break circuit breaker	Air at atmospheric pressure	400 V – 11 kV; 5-750 MVA
Minimum oil circuit breaker	Transformer oil	3.3 kV – 220 kV; 150 – 25000 MVA
Vacuum circuit breaker	Vacuum	3.3 kV – 33 kV; 250 – 2000 MVA
SF_6 circuit breaker	SF_6 at 5kg/cm^2 pressure	3.3 – 765 kV; 1000 – 50,000 MVA
Air blast circuit breaker	Compressed air at high pressure (20-30 kg/cm^2)	6.6 kV – 1100 kV; 2500 – 60,000 MVA

UNIT - II
ELECTROMAGNETIC AND STATIC RELAYS

electromechanical

- Robust and huge in size
- Moving parts—inertia-causes inherent time delay
- Disc rotates on bearing –friction causes time delay
- Dust,magnetic particles attracts to brake magnet and influences the operation
- Plugs or rotating knobs for adopting settings
- One function =one relay
- Requires maintenance and monotiring

static

- Size became less
- No moving parts
- improved performance
- Still same for settings adoption
- Self diagnostic feature

Static Relays

- Static relays are those in which the designed response is developed by electronic or magnetic means without mechanical motion.
- The designation ‘static relay’ covers the electronic relays of both the analog and digital designs.
- The analog relays refer to electronic circuits with discrete devices like transistors, diodes, etc., which were adopted in the initial stages.
- The digital designs incorporate integrated chips, microprocessors, etc., which had been developed subsequently.
- Most modern overcurrent relays are of the digital type.
- The main objective of using static relays is to improve the sensitivity, speed and reliability of a protection system by removing the delicate mechanical parts that can be subject to wear due to vibration, dust and corrosion.

Static Comparators as Relays

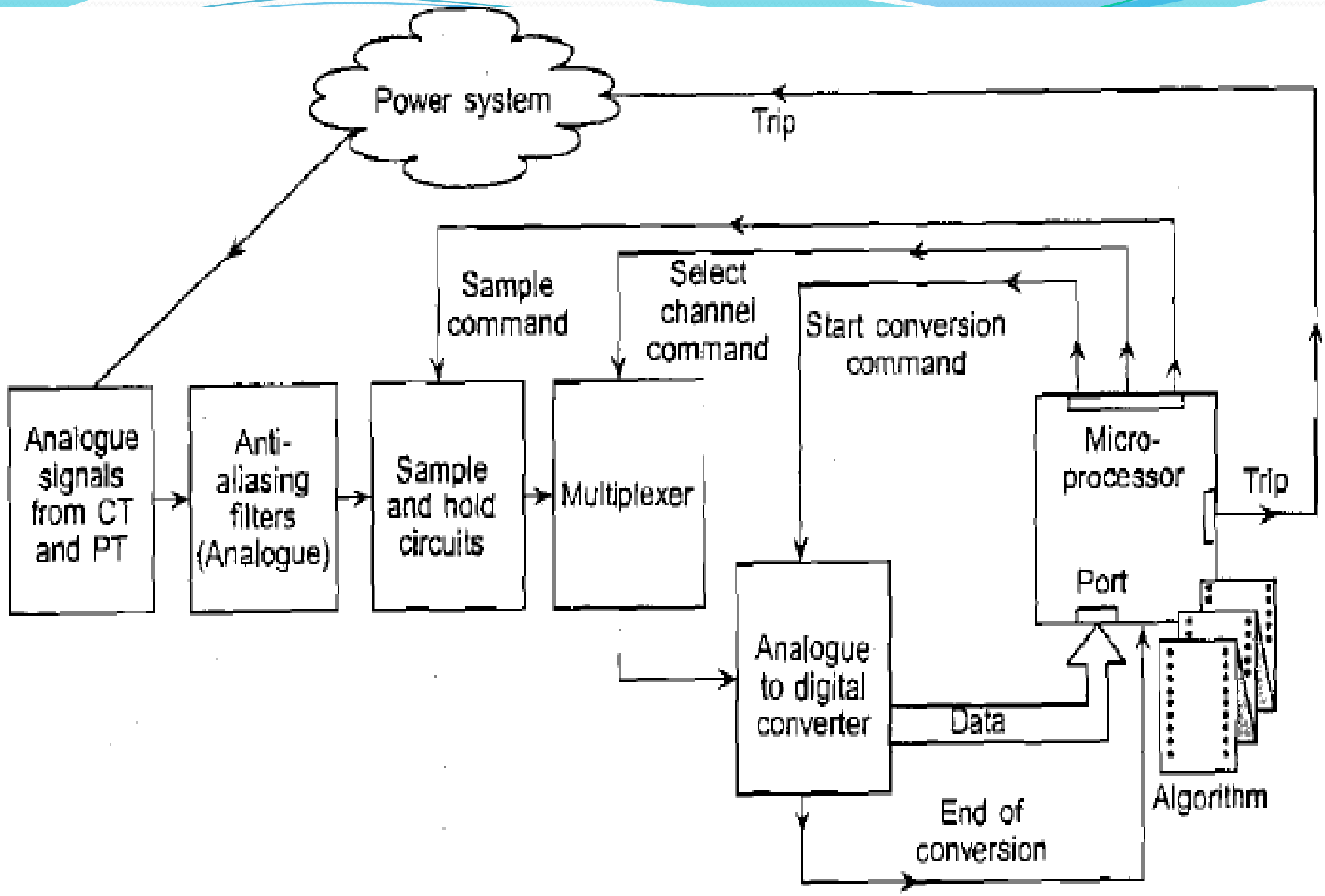
Comparison vs Computation

- An over-current relay compares the magnitude of the current in its current coil with a set value and operates if the current is more than the set value.
- A directional relay compares phase angle of the measured quantity (i.e. current) with a reference phasor (i.e.voltage) and operates if this phase angle exceeds a predetermined threshold.
- All the relays perfom some or the other kind of comparison. Thus, at the heart of any relay, is always a comparator.
- Historically, these comparators were implemented using electromechanical technology.
- But eventually the electromechanical relays gave way to the solid-state relays.

Numerical Relays

- Microprocessor-based relay, works on numbers representing instantaneous values of the signals. Hence, they are named **numerical relay.** Other popular nomenclatures for such relays are **digital relay,computer-based relay** or **microprocessor-based relay.**
- In numerical relays, the software, runs in the background and which actually runs the relay.
- What distinguishes one numerical relay from the other generally is the software.
- Conventional relay performs comparison only .
- The numerical relay does not have any such limitation because of its ability to perform real-time computation.
- Existlng relaying concept can be implemented using the numerical technique.
- The possibilities of developing a new numerical relay are almost endless and there is very little standardization.

Block Diagram of Numerical Relay



Transmission Line Protection

Distance Relays: -

Introduction:

- The impedance relays also called distance relays are employed to provide protection to transmission lines connected in a network as they are economic and possess several technical advantages. They are comparatively simple to apply, operate with extremely high speed, and both primary and backup protection features are inherent in them.

Additional Features in distance schemes:

i) Power Swing blocking relay
ii) VT fuse failure relay.
iii) Switch onto fault relay
iv) Fault locator
v) Auto-reclosing scheme.
vi) Carrier communication scheme.

Switch onto fault: -

- When the line is switched on to a close by fault (say after line clear with earth switch closed), the voltage at the relaying point will be zero. Faults of this type will normally be cleared by backup zones.
- The voltage applied to the relay is low and this condition occurring simultaneously with the operation of starter will cause instantaneous trip by SOTF relay. This SOTF feature will be effective only for about 1-2 seconds after the line is charged. Faults occurring after this time will be measured in the normal way.

Types of Auto-reclosing schemes (based on phase):

a) Three phase Auto-reclosing:

- This type of auto-reclosing causes an immediate drift apart of the two systems and hence no interchange of synchronizing power can take place during the dead time.

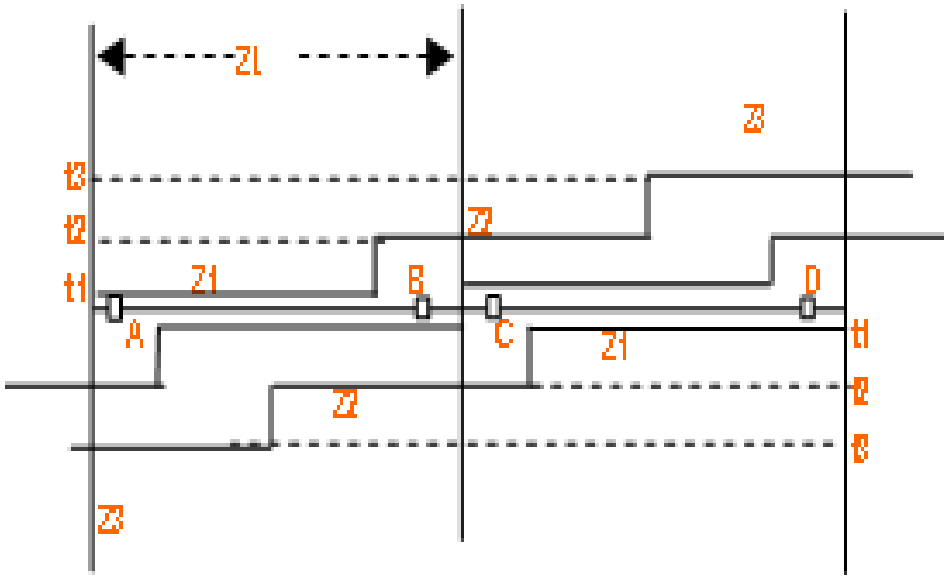
b) Single Phase Auto-reclosing:

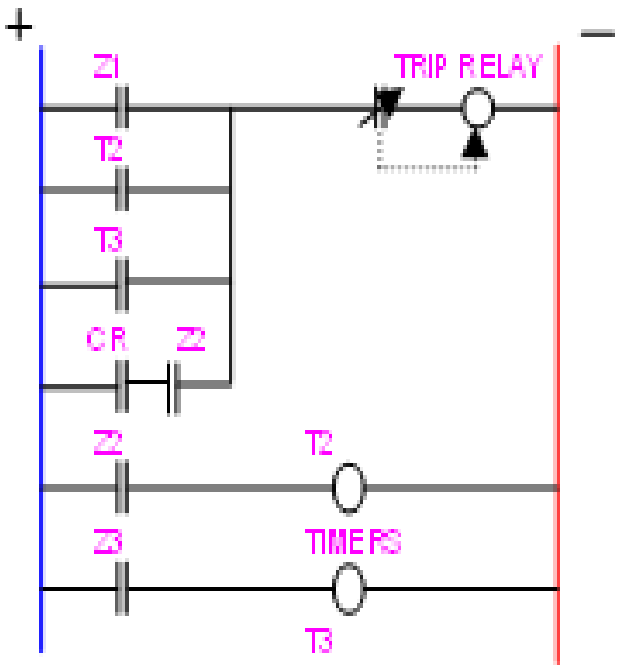
- In this only the faulty phase (which already has tripped on SLG fault) is reclosed without causing interruption in interchange of synchronizing power between two systems through other two healthy phases.

Transfer trip is of two types:-

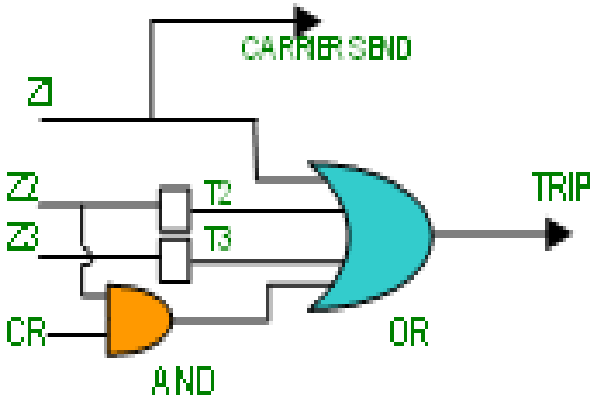
Under-reaching scheme:-

- The scheme in which the Zone-1 relay (set to cover about 80% of ZL) is used to send a signal to the remote end of the feeder for inter-tripping is termed as transfer trip under-reaching scheme. To avoid mal-operation due to receipt of false signal, the receiving end relay operation is inter-locked with its Zone-3/starter operation i.e. the scheme operates either by its own Zone-1 relay operation or by receipt of carried and its Zone-3/starter operation.



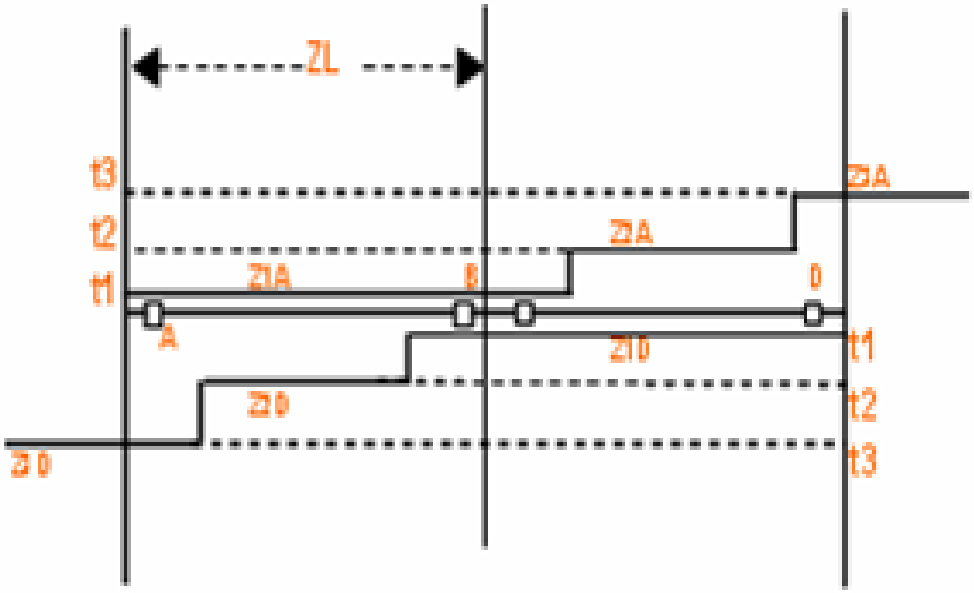


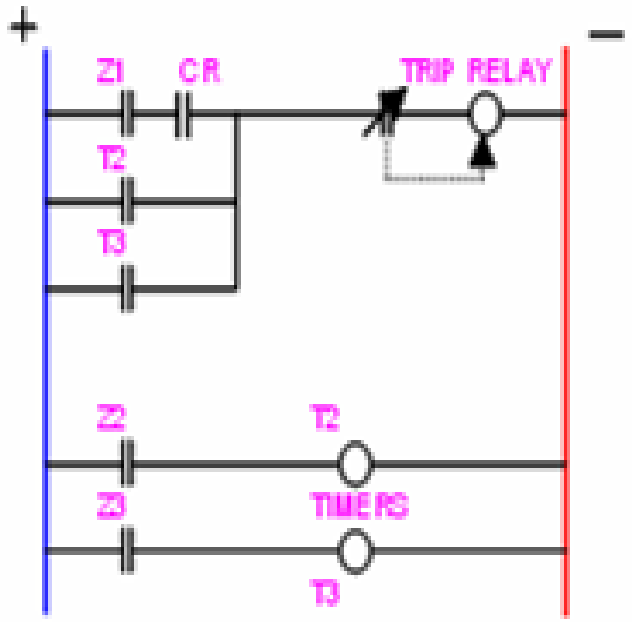
CARRIER SEND =Z1			
TRIP =Z1 + Z2*(CR+T2) + Z3*T3			



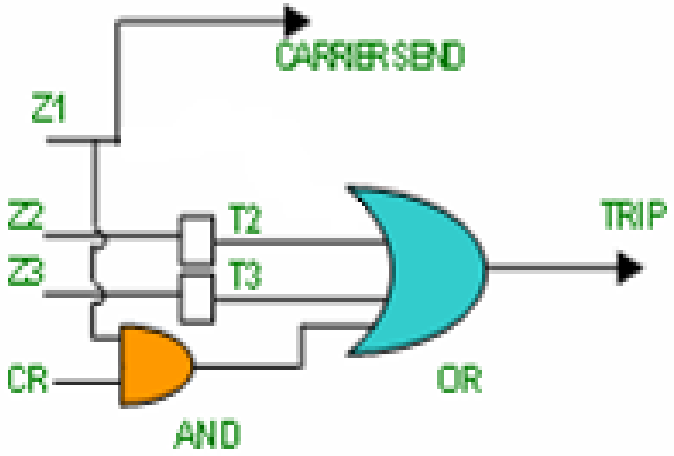
Over-reaching scheme:-

- This scheme is suitable for short lines where an underreaching Zone-1 would be too short to be of any practical use. In this scheme the relay set to reach beyond 100% of the line, is used to send an inter-tripping signal to the remote end of the line. It is essential that the receive relay contact be monitored by a directional relay to ensure that tripping does not take place unless the fault is within the protected section. The disadvantage of this scheme is that there is no independent Zone-1 tripping. The fast tripping therefore relies entirely on signaling channel.
- The disadvantages of these schemes is that the signal is transmitted over the fault line section. Distortion of the signal may occur due to attenuation introduced into the line by the fault.



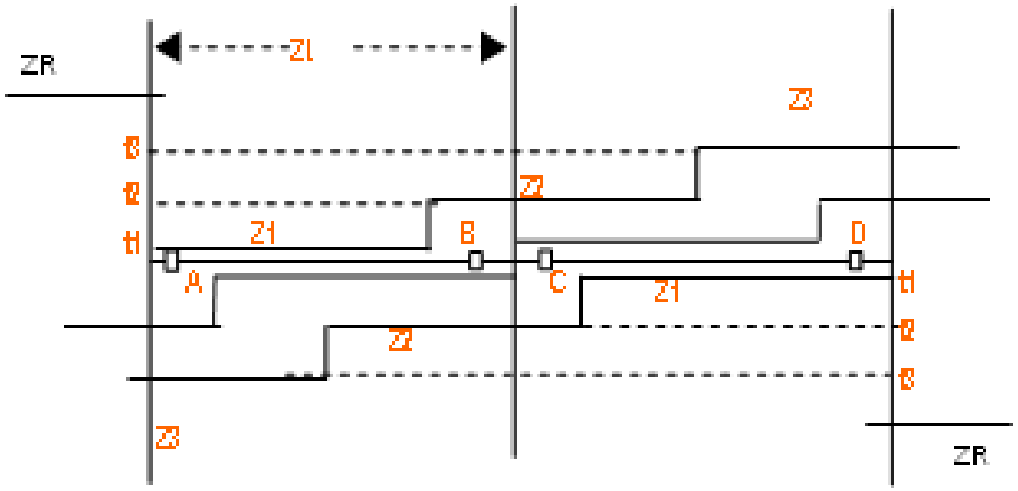


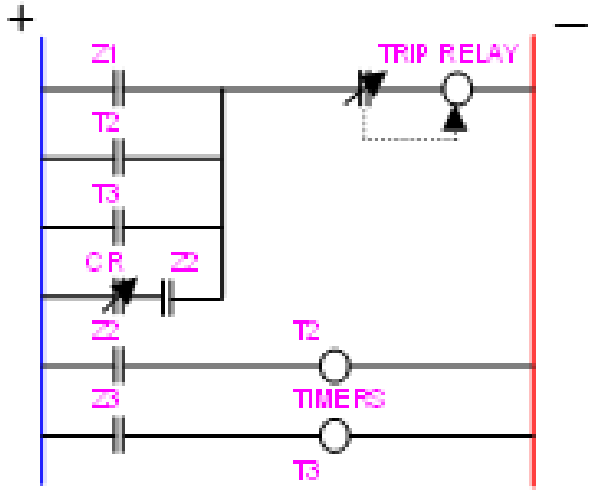
	CARRIER SEND =Z1		
	TRIP =Z1'CR + Z2'T2 + Z3'T3		



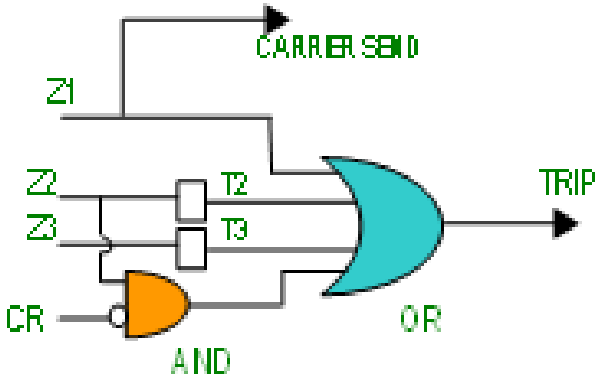
b) Blocking schemes:-

- In this scheme, a blocking signal is sent by the reverse looking directional unit ZR to prevent instantaneous tripping for Zone-2 & Zone-3 faults, external to the protected line. Here ZR must operate faster then forward looking Zone-3 units and the signaling channel must also be extremely fast is operation.





	CARRIER SEND =ZR			
	TRIP = Z1 + Z2* ($\overline{CR}$ * To+T2) + Z3*T3			



Factors affecting distance relay operation:-

i) Fault resistance.

ii) Infeed effect.

iii) Branching-off effect.

iv) Load encroachment.

Fault resistance:-

Fault resistance has two components:-

a) Arc resistance.

b) Ground resistance.

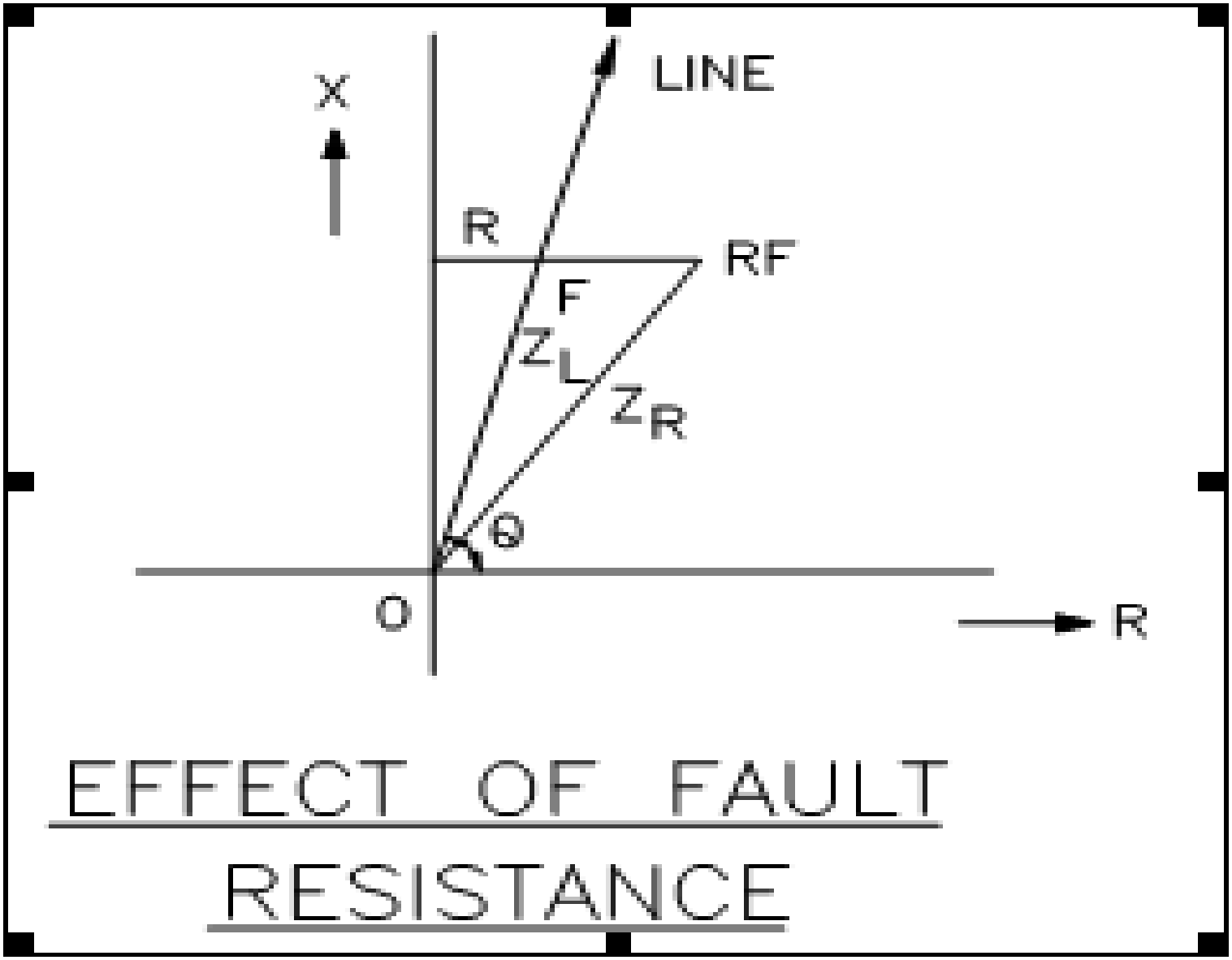
In a fault between phases, only arc resistance is involved.

For a fault at F, the actual line impedance

$= R + JX = ZL$

Due to the presence of fault resistance, the impedance measured by the relay

$= R + JX + RF = ZR$ (where $ZR > ZL$)



EFFECT OF FAULT RESISTANCE

Fault arc resistance is given by Warrington's formula:

$$R_{arc} = 8750 \times l / I^{1.4}$$

where l = length of arc in ft

I = fault current in Amps

UNIT - III
GENERATOR AND TRANSFORMER PROTECTION

Kinds of Faults Generators are Subjected to

- **Due to problems within generator**
- Stator ground faults
- Stator phase faults
- Stator inter-turn faults
- Rotor ground faults
- Duplicate ground faults

- **Due to external conditions**
- Phase faults
- Asymmetric faults
- Stator overload
- Rotor overload
- Over-voltage
- Under-frequency
- Motoring

Stator Ground Fault Protection

- One of the most frequent internal generator faults
- Fault current will depend on the method of grounding
- High fault currents will cause damage to the core
- Limitation of the fault current to low values reduces
  - damage to the core
  - possibility of developing into phase-phase faults

Methods of Limiting Erath Fault Currents

- Resistance earthing
- Distribution Transformer earthing

Generator Directly Connected to the Power System

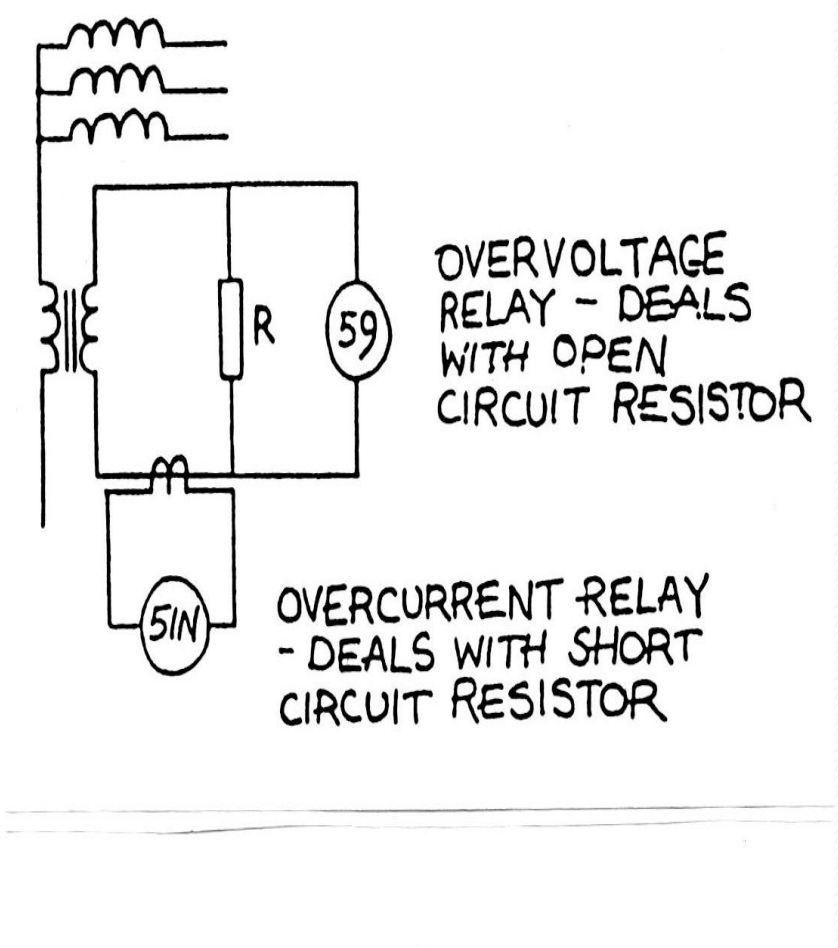
- Generally only low capacity generators connected directly to the busbars
- Discrimination required
- Placement of the CTs
- Measurement of the earth-fault current
  - Core balance CT
  - Residual connection
- Simple Current Relays, Restricted earth fault, Directional relays

Generators Connected Through a Stepping Up Transformer

- As primary winding is delta, earth faults on the HV side are not seen by the generator earth fault relays
- Instantaneous and time delayed relays could be used
- Relay settings need to be set to avoid operation for surges through generator transformer inter-winding capacitance.
- As discrimination is not required, earth fault currents can be limited to low values
- Standard arrangement is to earth the neutral through the primary winding of a transformer
-

Distribution Transformer Method of Earthing Generator Neutral

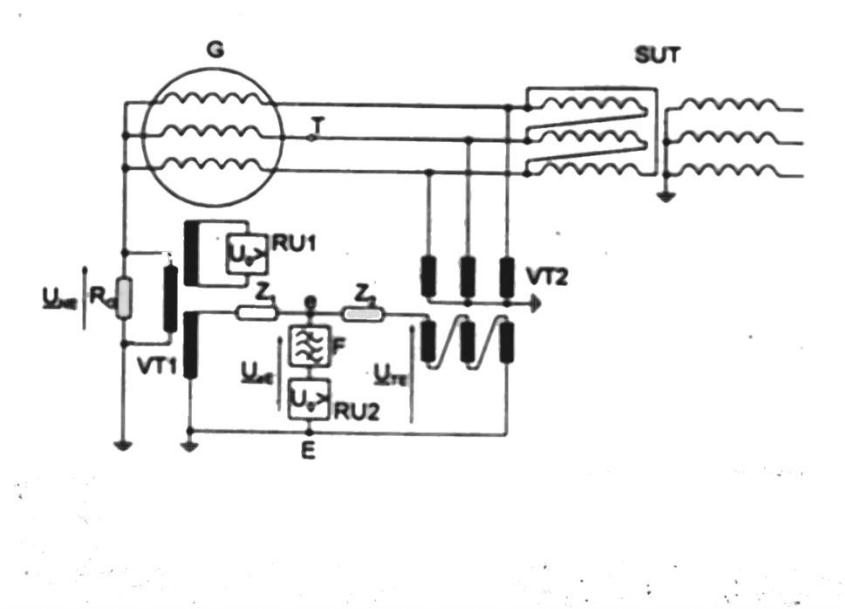
- Transformer secondary winding designed for (100 - 500V) and is loaded with a resistor
- Under earth fault conditions a current will flow in the secondary
- Over voltage or over current relay could be employed
- These could provide only 90-95% of the stator winding.

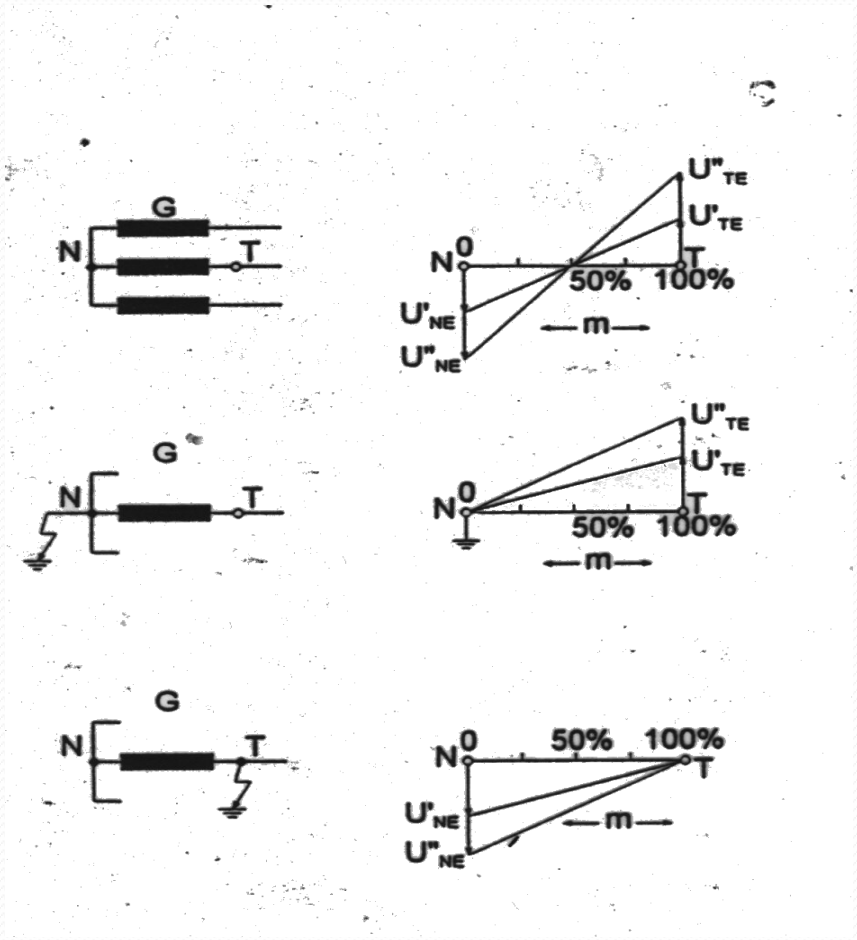


100% Protection of Generator Stator Winding

- 3^{rd} harmonic components exist in the generator phase voltages.
- Under normal operating conditions 3^{rd} harmonic voltages highest at the star point and at the generator terminals
- With EF close to neutral 3^{rd} harmonic at the terminals get doubled and that at the neutral reduces to zero.
- With EF at the terminals, 3^{rd} harmonic at the neutral will be high.
- EF at the centre of the stator winding can not be detected
- Can not detect ground faults when the generator is not running.

Third Harmonic Method – 100% Stator Earth Fault Protection

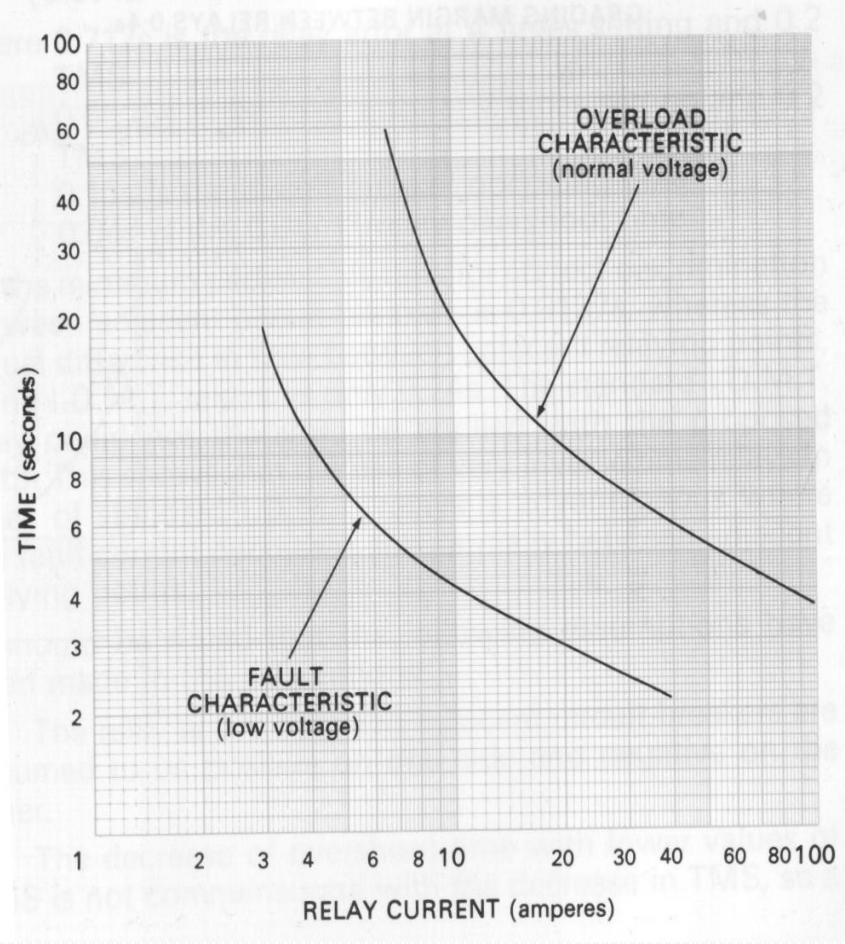




Generator Backup Protection

- Voltage restrained over current

- Voltage controlled over current



Stator Inter-turn Faults

- Longitudinal differential systems do not detect interturn faults

- Interturn fault protection not commonly provided as those are rare or later will develop into earth faults

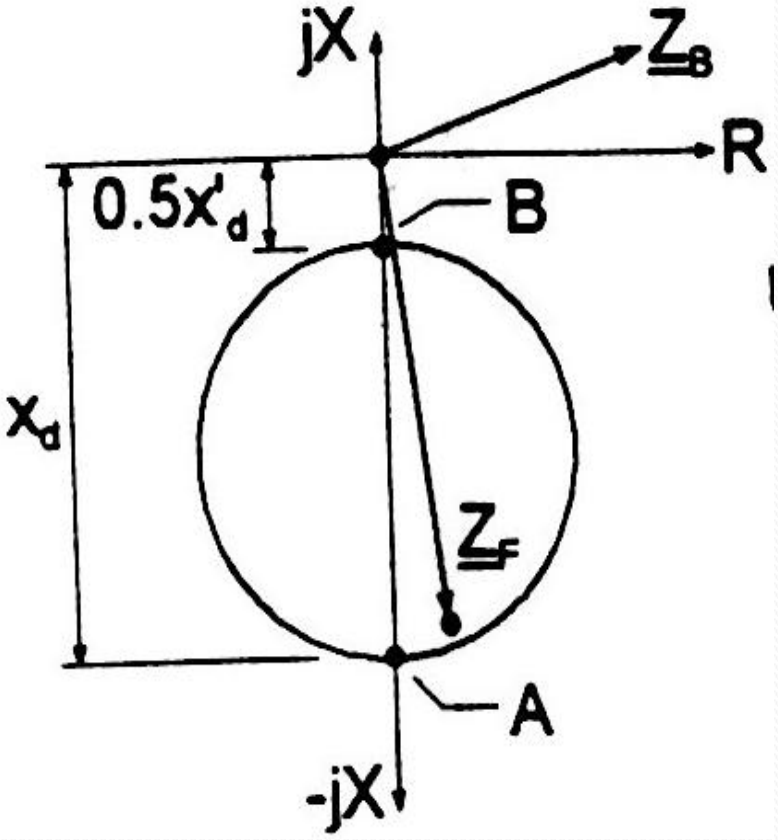
Loss of Excitation

- Short or open circuit of the exciter
- Failure of the automatic voltage regulator
- Operational error under manual control

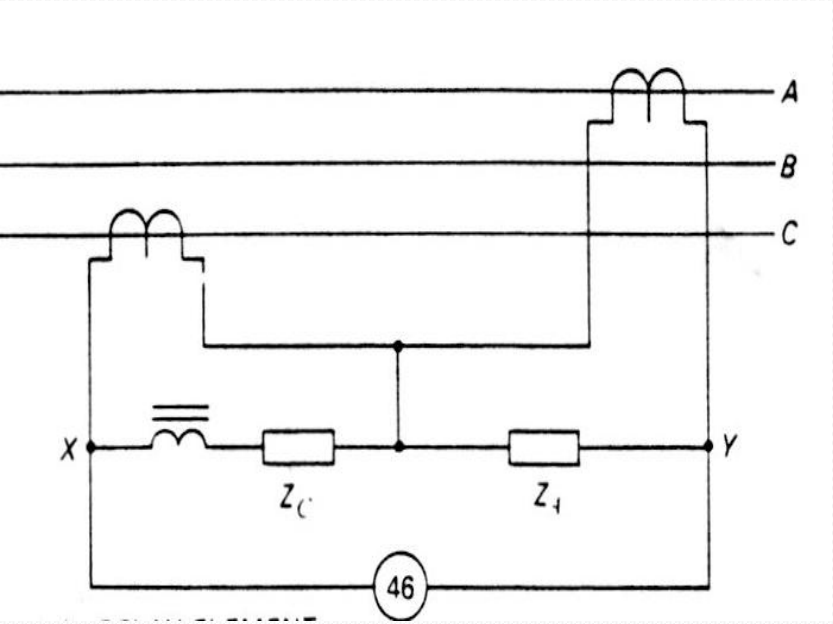
- Cause partial or complete failure of the the excitation
- Local hot spots in stator or rotor
- Falling out of synchronism with paralllel running of generators
- With single generator load will be lost

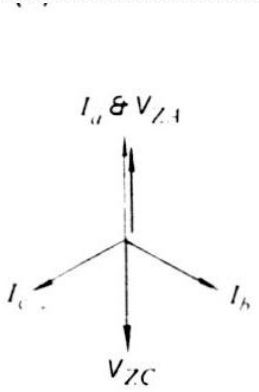
Loss of Excitation Protection

- Causes the generator to draw excitation current from the system
- This is equivalent to supplying capacitive current
- Impedance vector at the generator terminals shifts from the first to the fourth quadrant of the R/X plane.
- Impedance reaches synchronous reactance first and then the transient reactance
- Monitoring of the generator terminal voltage and the excitation current absorbed from the system

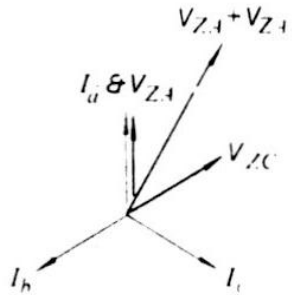


Negative Sequence Protection



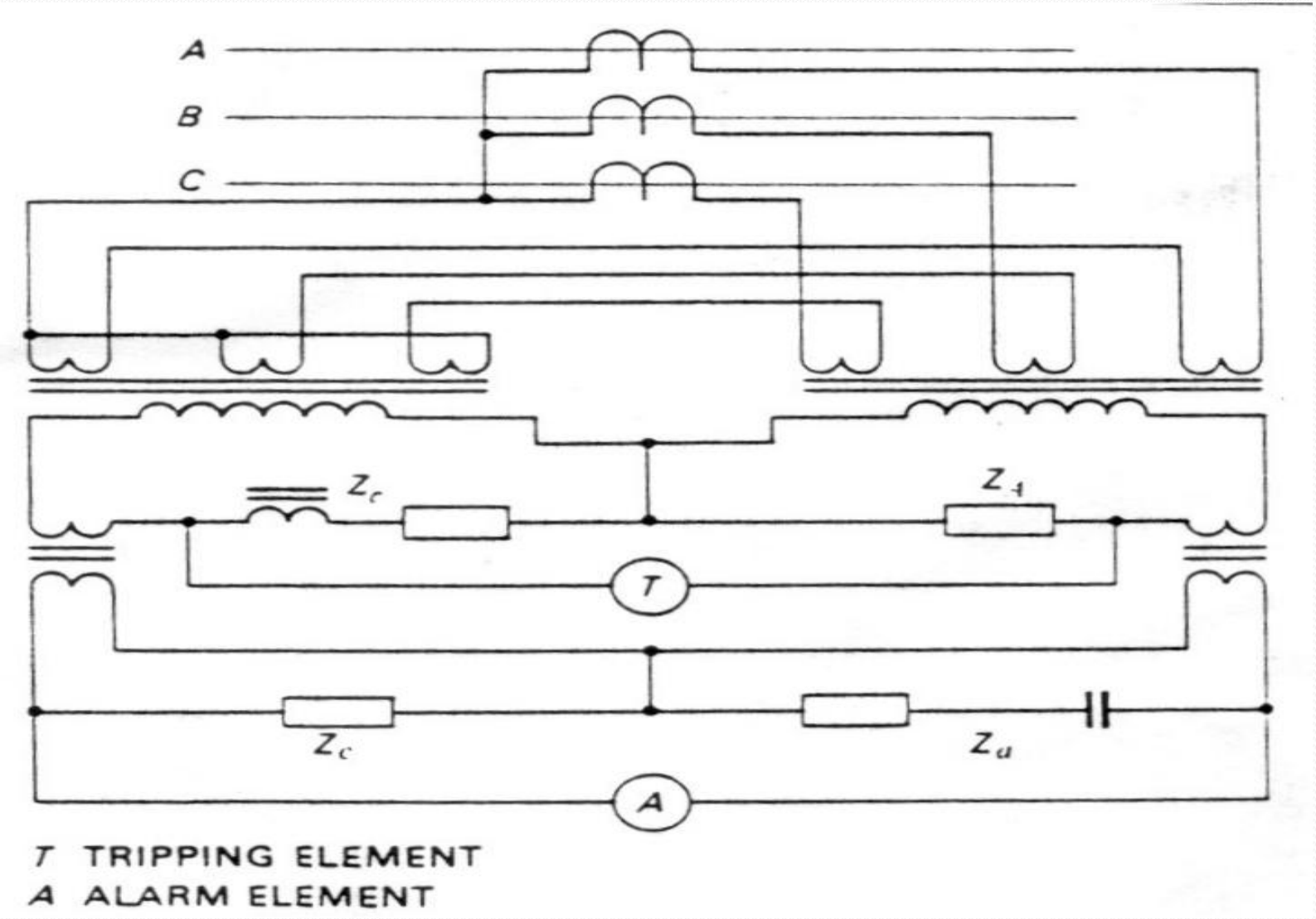


(b) POSITIVE SEQUENCE



(c) NEGATIVE SEQUENCE

Negative Sequence Protection



Rotor Earth Faults

- Field current is an isolated DC system
- Insulation failure at a single point produces no fault current
- Insulation failure at the second point shorts part of the field winding, heating the conductors, flux distortion, vibration of the rotor.
-

Over Voltage Protection

- Over voltage results from
  - generator over speed caused by sudden loss of load
  - Failure of the voltage regulator
  - Causes over fluxing and endangers insulation
- Time delayed over voltage protection schemes are provided

Reverse power

- Generator can act as a motor drawing power from the system
- Prime mover gets affected
- Wattmetric type relays are used

UNIT - IV
FEEDER AND BUS-BAR PROTECTION AND GROUNDING: PROTECTION OF LINE

DIFFERENTIAL PROTECTION SCHEME CONT…….

OPEARTION

- UNDER NORMAL CONDITIONAL OR EXTERNAL FAULT CONDITIONS, THE SUM OF THE CURRENT ENTERING THE BUS BAR IS EQUAL TO THE SUM OF CURRENT LEAVING IT. THEREFORE, NO CURRENT FLOWS THROUGH THE OPERATING COIL. HOWEVER, WHEN FAULTS OCCURS WITHIN THE PROTECTED ZONE (BUS- BAR), THE CURRENT ENTERING THE BUS-BAR WILL NO LONGER BE EQUAL TO THOSE LEAVING IT. THUS, A DIFFERENTIAL CURRENT FLOWS THROUGH THE OPERATING COIL OF THE RELAY WHICH CLOSES THE TRIP CIRCUIT.

PROTECTION REQUIREMENTS

HIGH BUS FAULT CURRENTS DUE TO LARGE NUMBER OF CIRCUITS CONNECTED:

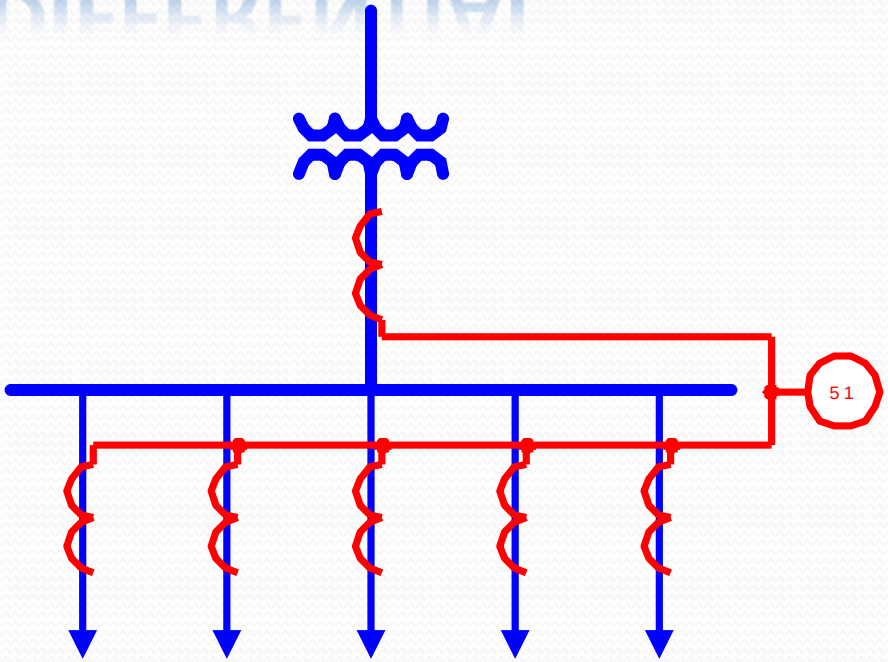
- **CT SATURATION OFTEN BECOMES A PROBLEM AS CTS MAY NOT BE SUFFICIENTLY RATED FOR WORST FAULT CONDITION CASE**
- **LARGE DYNAMIC FORCES ASSOCIATED WITH BUS FAULTS REQUIRE FAST CLEARING TIMES IN ORDER TO REDUCE EQUIPMENT DAMAGE**

FALSE TRIP BY BUS PROTECTION MAY CREATE SERIOUS PROBLEMS:

- **SERVICE INTERRUPTION TO A LARGE NUMBER OF CIRCUITS**
- **SYSTEM-WIDE STABILITY PROBLEMS**

WITH BOTH DEPENDABILITY AND SECURITY IMPORTANT, PREFERENCE IS ALWAYS GIVEN TO SECURITY.

OVER-CURRENT (UNRESTRAINED) DIFFERENTIAL



- DIFFERENTIAL SIGNAL FORMED BY SUMMATION OF ALL CURRENTS FEEDING BUS.
- CT RATIO MATCHING MAY BE REQUIRED.
- ON EXTERNAL FAULTS, SATURATED CTS YIELD SPURIOUS DIFFERENTIAL CURRENT.
- TIME DELAY USED TO COPE WITH CT SATURATION.

LINEAR COUPLERS

ESEC= IPRIM*XM - SECONDARY VOLTAGE ON RELAY TERMINALS

IR= ΣIPRIM*XM /(ZR+ΣZC) – MINIMUM OPERATING CURRENT

WHERE,

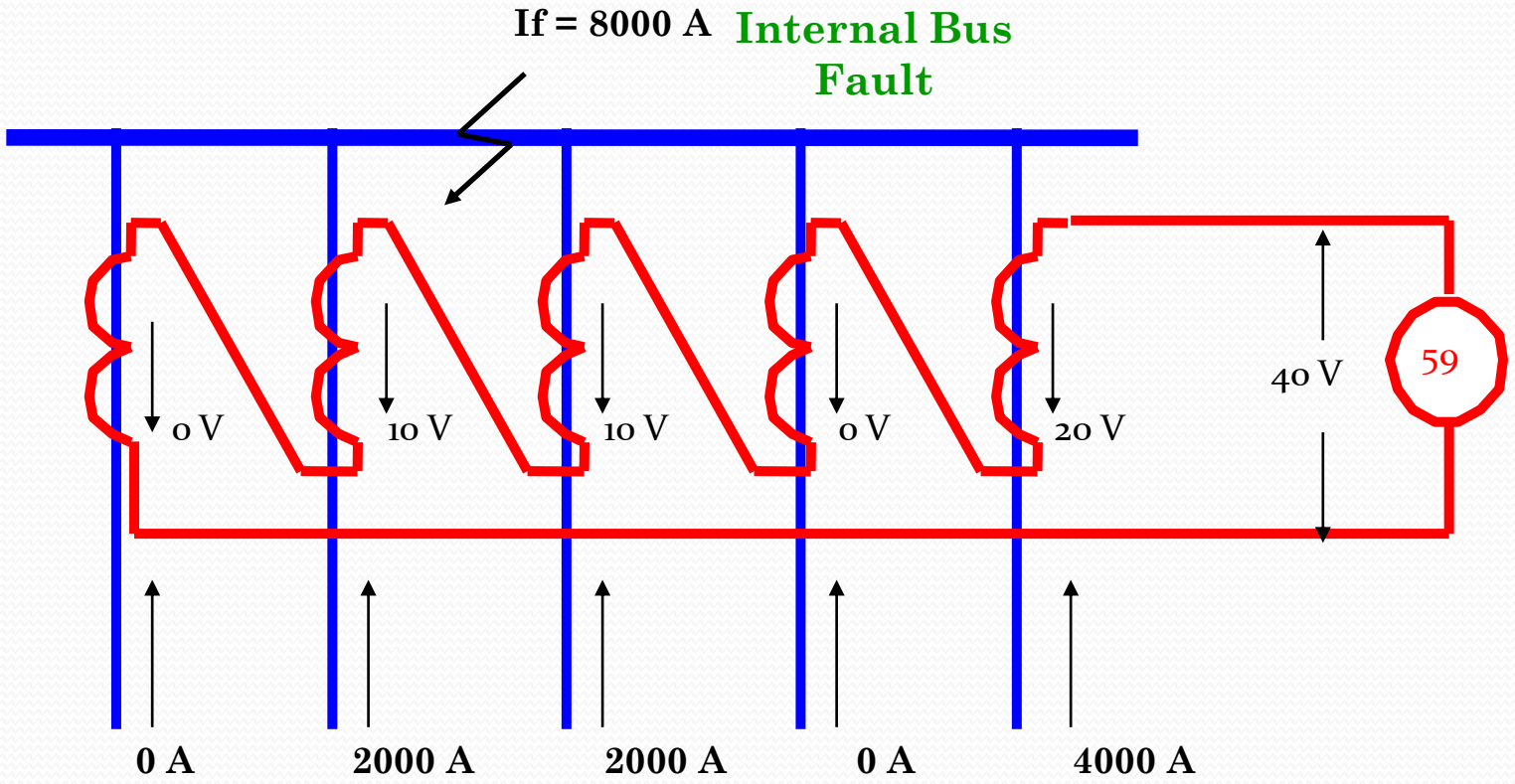
IPRIM – PRIMARY CURRENT IN EACH CIRCUIT

XM–LINER COUPLER MUTUAL REACTANCE (5V PER 1000AMPS => 0.005Ω @ 60HZ),

ZR – RELAY TAP IMPEDANCE

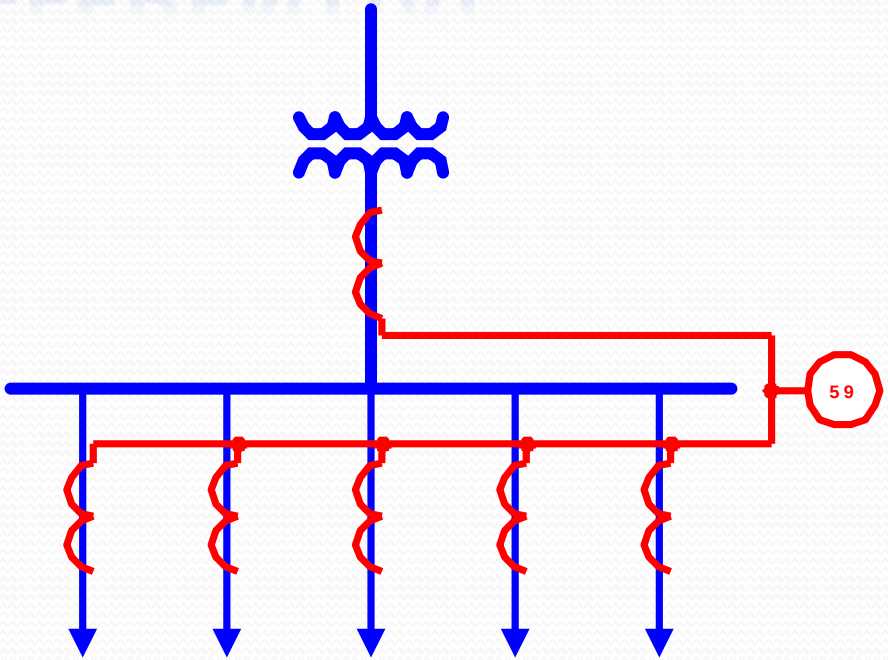
ΣZC – SUM OF ALL LINEAR COUPLER SELF IMPEDANCES

LINEAR COUPLERS



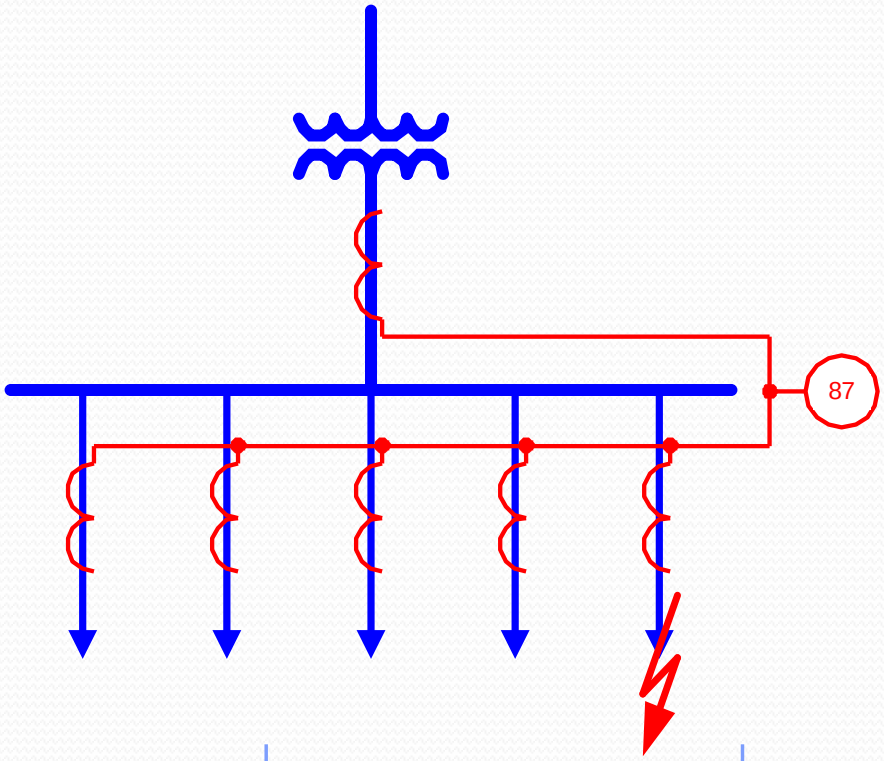
HIGH IMPEDANCE DIFFERENTIAL

- OPERATING SIGNAL CREATED BY CONNECTING ALL CT SECONDARY'S IN PARALLEL.
- CTS MUST ALL HAVE SAME RATIO.
- MUST HAVE DEDICATED CTS
- OVERVOLTAGE ELEMENT OPERATES ON VOLTAGE DEVELOPED ACROSS RESISTOR CONNECTED IN SECONDARY CIRCUIT.
- REQUIRES VARISTORS OR AC SHORTING RELAYS TO LIMIT ENERGY DURING FAULTS.
- ACCURACY DEPENDENT ON SECONDARY CIRCUIT RESISTANCE.
- USUALLY REQUIRES LARGER CT CABLES TO REDUCE ERRORS ⇒ HIGHER COST



CANNOT EASILY BE APPLIED TO RECONFIGURABLE BUSES AND OFFERS NO ADVANCED FUNCTIONALITY

PERCENT DIFFERENTIAL



$$I_{DIF} = \left| I_1 + I_2 + \ldots + I_n \right|$$

$$I_{RES} = \left| I_1 \right| + \left| I_2 \right| + \ldots + \left| I_n \right|$$

$$I_{RES} = \max\left(\left| I_1 \right|, \left| I_2 \right|, \ldots, \left| I_n \right| \right)$$

- PERCENT CHARACTERISTIC USED TO COPE WITH CT SATURATION AND OTHER ERRORS.
- RESTRAINING SIGNAL CAN BE FORMED IN A NUMBER OF WAYS.
- NO DEDICATED CTS NEEDED.
- USED FOR PROTECTION OF RE-CONFIGURABLE BUSES POSSIBLE.

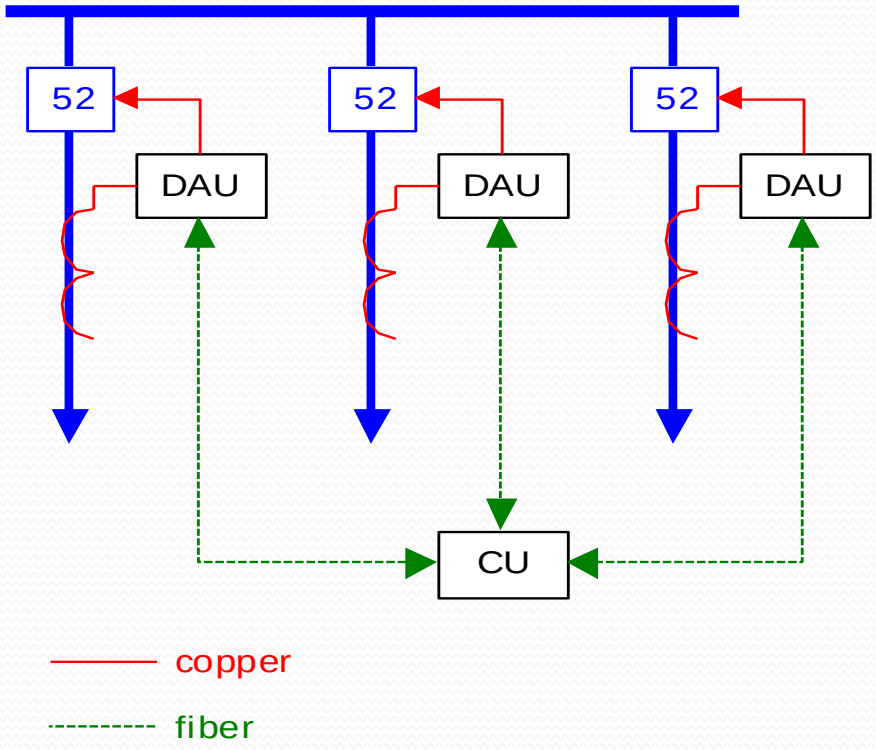
LOW IMPEDANCE PERCENT DIFFERENTIAL

- INDIVIDUAL CURRENTS SAMPLED BY PROTECTION AND SUMMATED DIGITALLY.
- CT RATIO MATCHING DONE INTERNALLY (NO AUXILIARY CTS).
- DEDICATED CTS NOT NECESSARY.
- ADDITIONAL ALGORITHMS IMPROVE SECURITY OF PERCENT DIFFERENTIAL CHARACTERISTIC DURING CT SATURATION.
- DYNAMIC BUS REPLICA ALLOWS APPLICATION TO RECONFIGURABLE BUSES.

LOW IMPEDANCE PERCENT DIFFERENTIAL

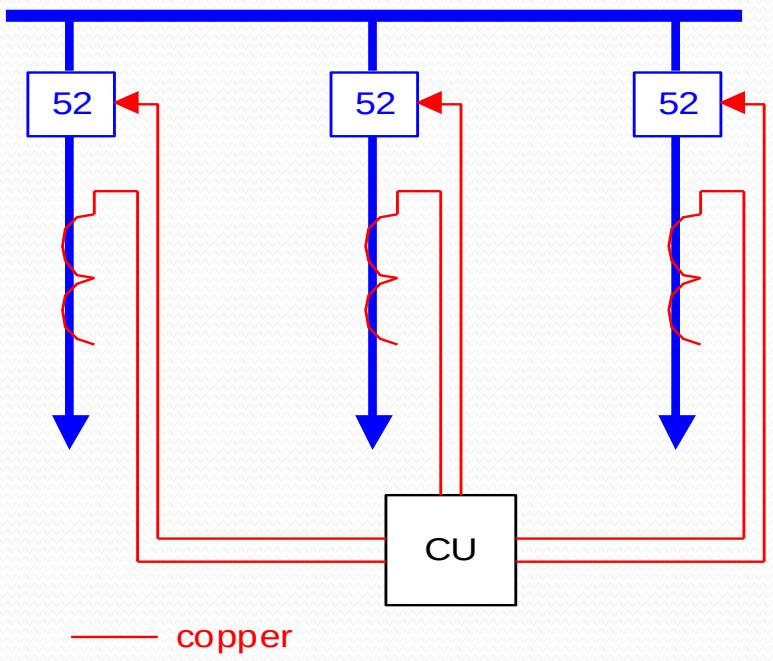
- DONE DIGITALLY WITH LOGIC TO ADD/REMOVE CURRENT INPUTS FROM DIFFERENTIAL COMPUTATION.
- SWITCHING OF CT SECONDARY CIRCUITS NOT REQUIRED.
- LOW SECONDARY BURDENS.
- ADDITIONAL FUNCTIONALITY AVAILABLE.
- DIGITAL OSCILLOGRAPHY AND MONITORING OF EACH CIRCUIT CONNECTED TO BUS ZONE.
- TIME-STAMPED EVENT RECORDING.
- BREAKER FAILURE PROTECTION.

LOW IMPEDANCE DIFFERENTIAL (DISTRIBUTED)



- DATA ACQUISITION UNITS (DAUS) INSTALLED IN BAYS.
- CPU PROCESSES ALL DATA FROM DAUS.
- COMMUNICATIONS BETWEEN DAUS AND CPU OVER FIBRE USING PROPRIETARY PROTOCOL.
- SAMPLING SYNCHRONISATION BETWEEN DAUS IS REQUIRED.
- PERCEIVED LESS RELIABLE.
- DIFFICULT TO APPLY IN RETROFIT APP.

LOW IMPEDANCE DIFFERENTIAL (CENTRALIZED)



- ALL CURRENTS APPLIED TO A SINGLE CENTRAL PROCESSOR
- NO COMMUNICATIONS, EXTERNAL SAMPLING SYNCHRONISATION NECESSARY
- PERCEIVED MORE RELIABLE (LESS HARDWARE NEEDED)
- WELL SUITED TO BOTH NEW AND RETROFIT APPLICATIONS.

FEEDER PROTECTION

- THE CHANCES OF FAULTS OCCURING ON THE FEEDER (TRANSMISSION LINE) IS MUCH MORE DUE TO THEIR GREAT LENGTH AND EXPOSURE TO THE ATMOSPHERIC CONDITIONS. THEREFORE, VARIOUS PROTECTION SCHEMES HAVE BEEN DEVELOPED WHICH MAY BE CLASSIFIED AS:

A) TIME-GRADED OVER CURRENT PROTECTION

B) DIFFERENTIAL PROTECTION

C) DISTANCE PROTECTION

TIME GRADED OVER-CURRENT PROTECTION

- IN TIME GRADED OVER CURRENT PROTECTION SCHEME, THE TIME SETTING OF RELAY IS SO GRADED THAT IN THE EVENT OF FAULT, THE SMALLEST POSSIBLE SECTION OF THE SYSTEM POSSIBLE SECTION OF THE SYSTEM IS ISOLATED. THIS SCHEME IS APPLIED FOR THE PROTECTION OF

(A) RADIAL FEEDERS

(B) PARALLEL FEEDERS

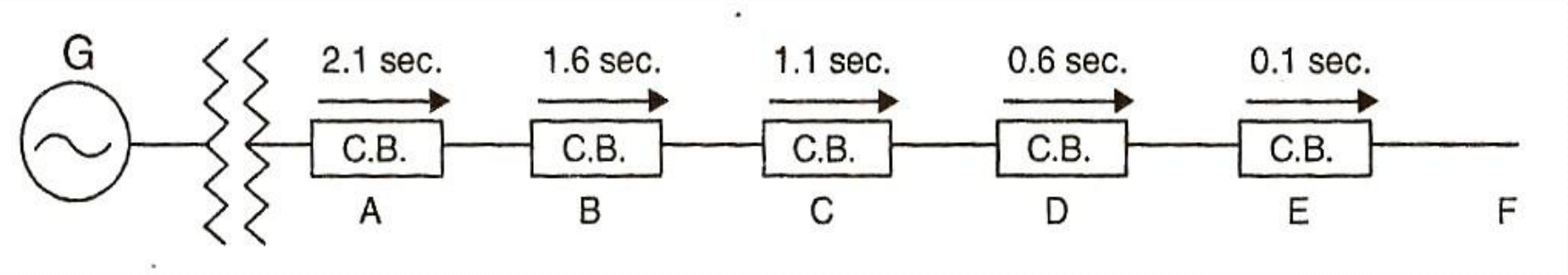
(C) RING MAINS

TIME-GRADED PROTECTION FOR RADIAL FEEDERS

- THE TIME-GRADED PROTECTION FEEDER IS OBTAINED BY EMPLOYING INVERSE DEFINITE MINIMUM TIME LAG RELAYS. THE RELAYS ARE SO SET THAT THE MINIMUM TIME OF OPERATION DECREASE FROM THE POWER STATION TO THE REMOTE SUB-STATION AS SHOWN IN FIG. IN NEXT SLIDE.

- THE OPERATING TIME OF INVERSE DEFINITE MINIMUM TIME LAG RELAYS IS INVERSELY PROPRTIONAL TO THE OPERATING CURRENT, BUT IS NEVER LESS THAN THE MINIMUM DEFINITE FOR WHICH IT IS SET.

TIME-GRADED PROTECTION FOR RADIAL FEEDERS CONT..



IF A FAULT OCCURS BETWEEN STATION E AND F, IT WILL BE CLEARED IN 0.1 SECOND BY THE RELAY AND CIRCUIT BREAKER OF SUBSTATION E BECAUSE ALL OTHER RELAYS HAVE HIGHER OPERATING TIME. IF THE RELAY AT SUB STATION E FAILS TO TRIP, THE RELAY AT D WILL OPERATE AFTER A TIME DELAY OF 0.5 SECONDS I.E. AFTER 0.6 SECONDS FROM THE OCCURRENCE OF FAULT.

TIME-GRADED PROTECTION FOR PARALLEL FEEDERS

- WHERE CONTINUITY OF SUPPLY IS ABSOLUTELY NECESSARY, TWO FEEDERS ARE RUN IN PARALLEL. IF A FAULT OCCURS ON ONE FEEDER, THE SUPPLY CAN BE MAINTAINED FROM THE OTHER FEEDER, DISCONNECTING THE FAULTY FEEDER. FOLLOWING FIG. SHOWS THE SYSTEM WHERE TWO FEEDERS ARE CONNECTED IN PARALLEL BETWEEN GENERATING STATION & SUB-STATION.
- AT THE GENERATING STATION, NON-DIRECTIONAL OVER CURRENT RELAYS ARE CONNECTED WHEREAS DIRECTIONAL OVER CURRENT INSTANTANEOUS RELAYS ARE CONNECTED AT SUB-STATION END.

TIME-GRADED PROTECTION FOR PARALLEL FEEDERS CONT....

- IF AN EARTH FAULT OCCURS ON FEEDERS AT POINT F AS SHOWN IN FIG. THE FAULT IS FED;

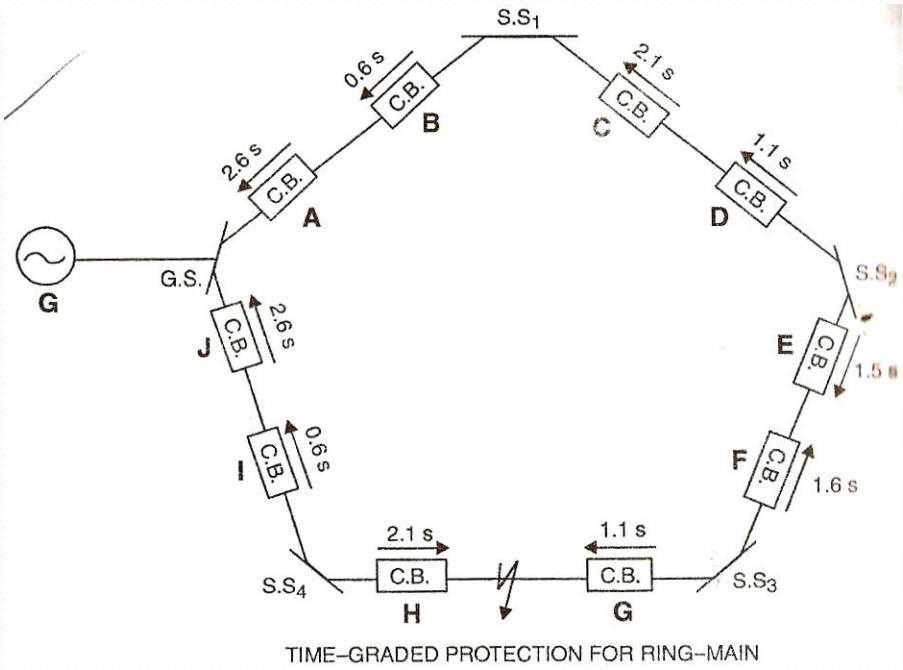
  (A) DIRECTLY FROM FEEDER 2 VIA RELAY B.

  (B) FROM FEEDER I VIA A , P AND SUB-STATION Q AS SHOWN IN FIG. BY THE DOTTED ARROWS.

THIS CLEARLY SHOWS THAT DIRECTIONAL RELAY P CARRIES THE CURRENT IN NORMAL DIRECTION WHERE AS DIRECTIONAL RELAY Q CARRIES THE CURRENT IN REVERSE DIRECTION MOMENTARILY. THIS OPEARATES THE RELAY Q INTANTANEOUSLY. THE RELAY B HAVING INVERSE TIME CHARACTERISTICS ALSO OPERATES BECAUSE OF HEAVY FLOW OF CURRENT .

TIME GRADED PROTECTION FOR RING-MAINS CONT……

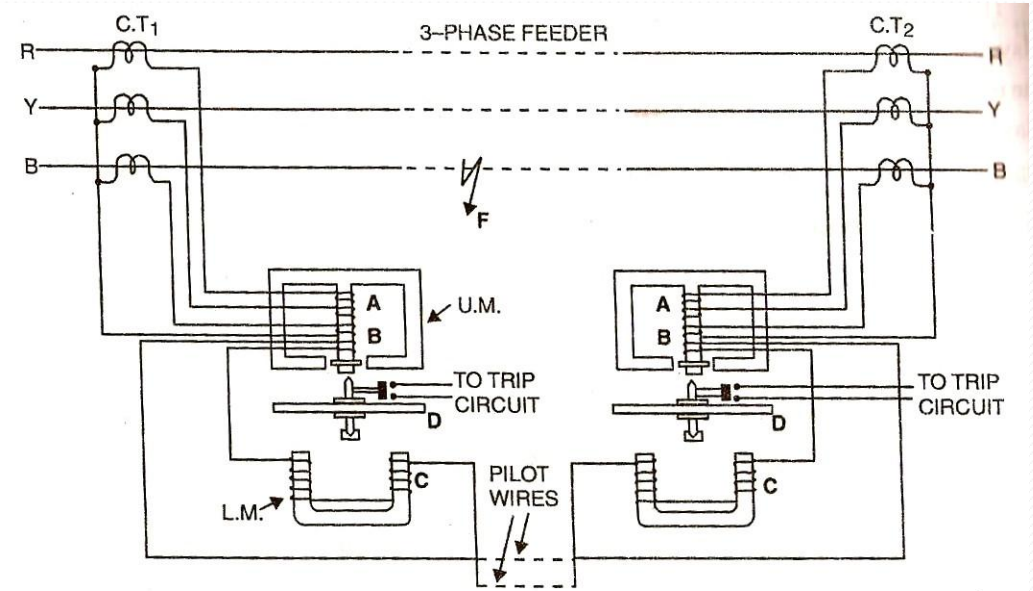
WHENEVER THE FAULT OCCURS ON ANY OF THE SECTION ONLY CORRESPONDING RELAYS WILL OPERATE WITHOUT DISTURBING THE OTHER RELAYS OF THE NETWORK, THUS, THE FAULTY SECTION IS ISOLATED AND SUPPLY IS MAINTAIN.



TIME–GRADED PROTECTION FOR RING–MAIN

DIFFERENTIAL PROTECTION (TRANSLAY SCHEME) CONT…

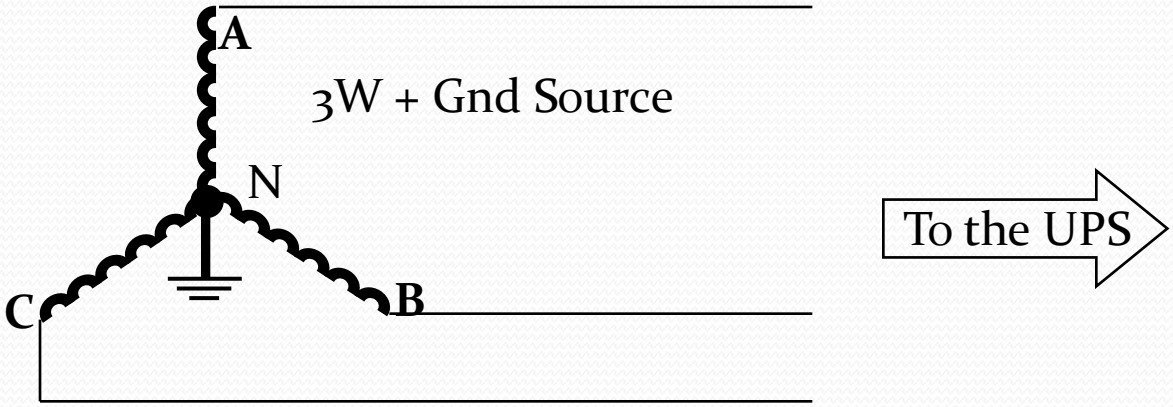
- THE CENTRAL LIMB OF THE UPPER MAGNET (U.M.) CARRIES A WINDING (A OR A') WHICH IS ENERGISED BY THE SUM OF SECONDARY CURRENTS OF CT'S PLACED ON FEEDER TO BE PROTECTED.



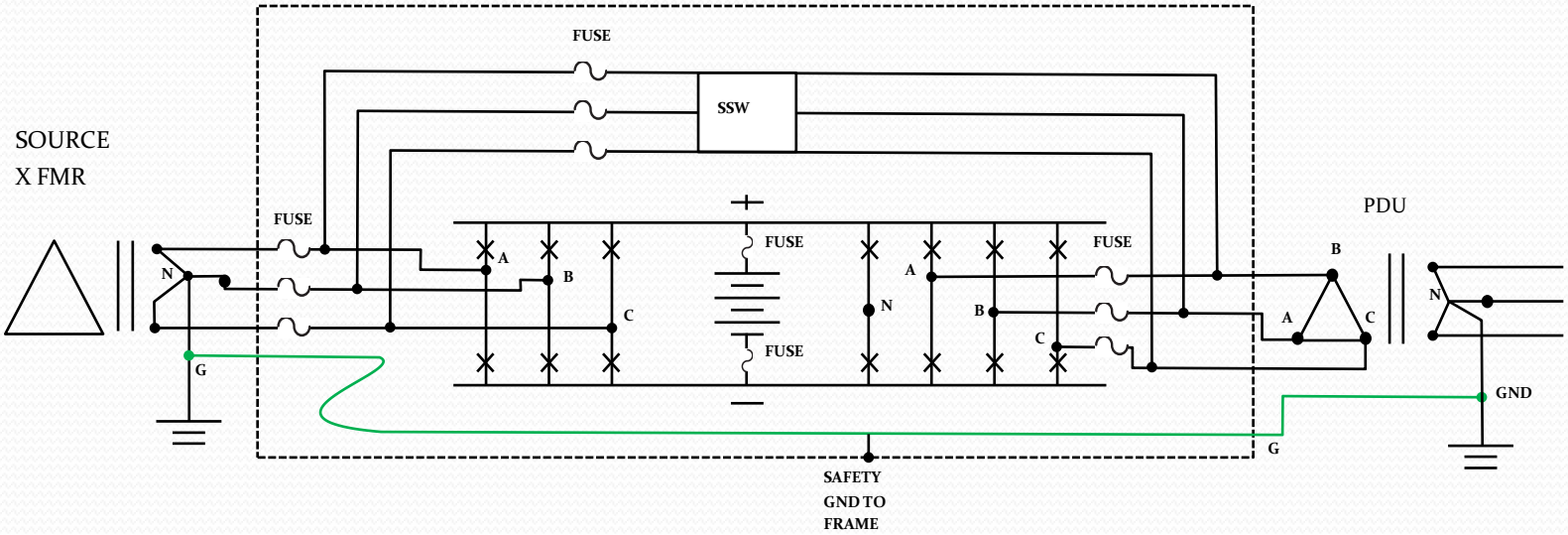
TRANSLAY SCHEME FOR FEEDER PROTECTION

What do I need to know about neutral handling in Eaton transformer-less UPS applications?

- Installation practices, especially in the U.S.
- Considerations when designing systems with transformer-less UPS
- How to answer engineers', installers', and inspectors' questions
  - What we recommend (and why), and what we will accept
  - How the transformerless UPS handles faults downstream of the UPS



Installation practices



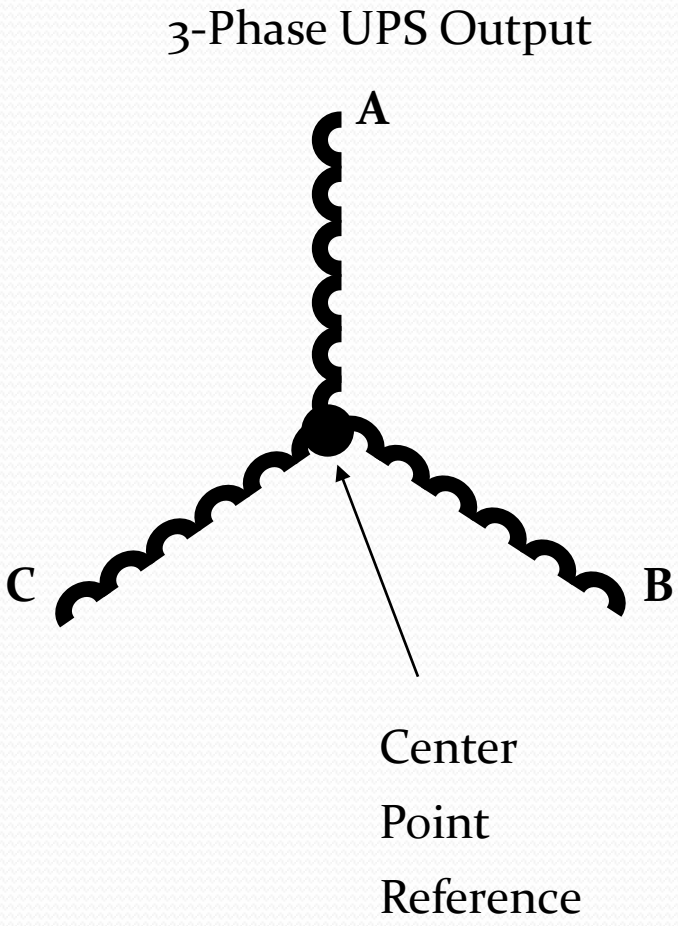
- North American power systems at 480V are almost exclusively fed through a "3-wire + ground" wiring system from "Wye" (neutral grounded) facility transformers. This is commonly known as a "3-wire solidly grounded system."

The neutral from the source transformer is not run to load-side equipment, AND it may not be necessary to run a neutral to the UPS.

- *Why not?* Because we <u>can</u> provide an internal center point reference, as long as we know that the source is 3W+G.

Neutral and Ground: What does the **UPS** require?

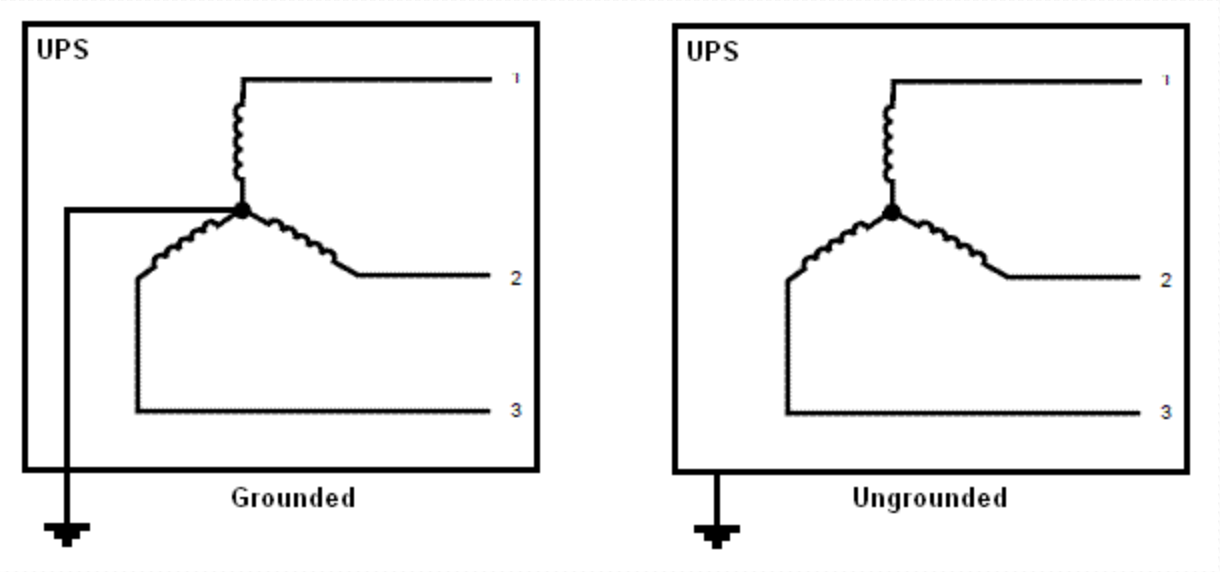
- **Safety:** protect personnel from hazardous voltages.
- **Performance:** The UPS requires a "center point reference" in order to create a 3-phase output, and keep it aligned with the bypass source. That "CP reference" could become a neutral under certain circumstances, but that is not always the case. The UPS only requires that the CP reference be stationary, not "moving around."
- **Fault Handling:** When an electrical fault occurs, the operation of circuit breakers and fuses function to limit the potential for electrical shock, and avoid a fire in the UPS. So their operation must be "predictable".



Battery Operation with ungrounded output

What does it mean that my UPS output is an ungrounded system? Is it safe? Will it work? What about faults?

- The UPS output Wye is ungrounded when on battery without a ground referenced center point.
- Transformer-less UPS pose no threat to the critical load during battery operation.
- The same safety requirements apply to both grounded and ungrounded systems. The UPS chassis still has a safety ground. The UPS frame will not rise above ground potential under any scenario
- Downstream distribution will locate the 3 phase conductors with respect to ground. This is the case with 480v to 208v PDUs.



Battery Operation - continued

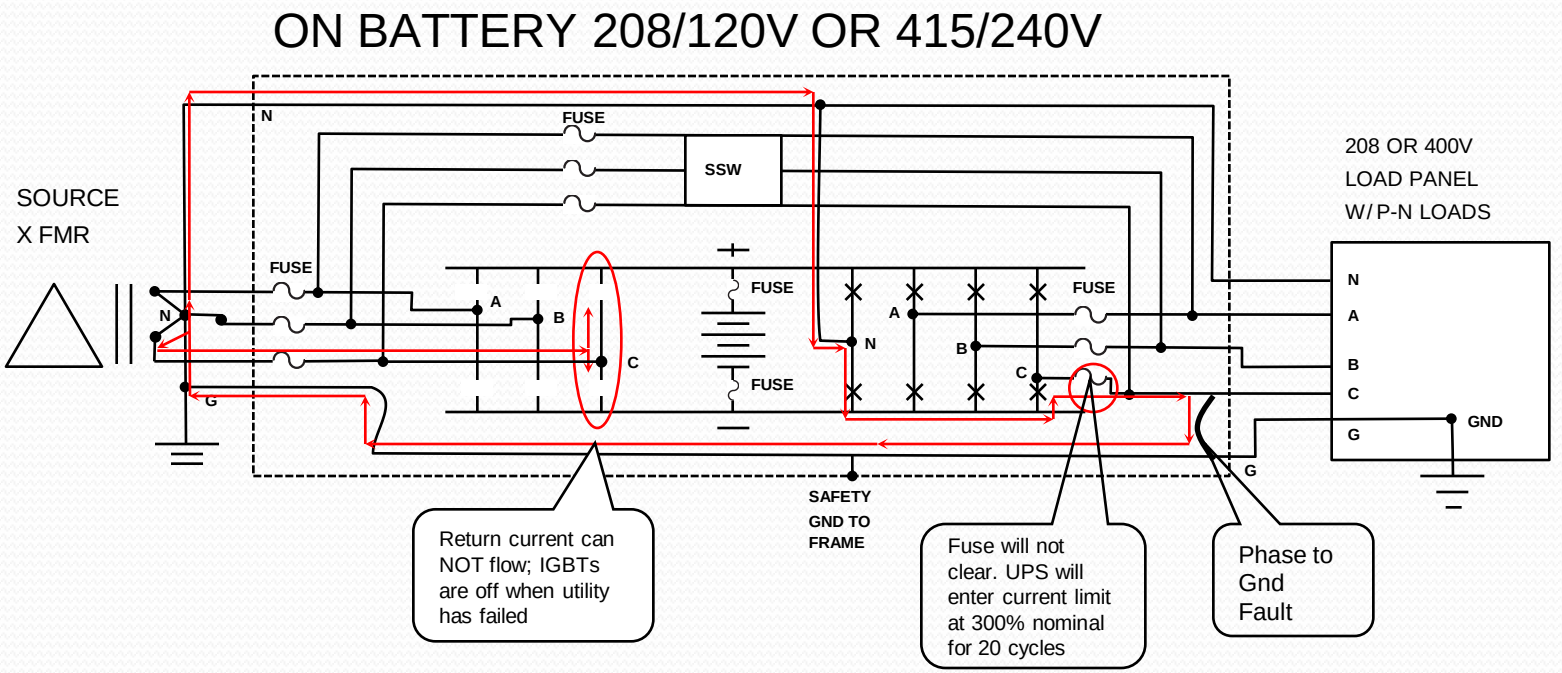
Is my load at risk?

- The NEC describes grounded systems as generating fault current upon the first phase-to-ground fault. Ungrounded systems generate current on the second fault.
- Two concerns with ungrounded systems include not detecting output faults, and ground fault detectors tripping “unexpectedly” upon the return of utility voltage.
  - Phase to ground faults while on battery are rare, but
  - We can set the UPS to shutdown on a detected fault while on battery
  - BTW, Load faults are ALWAYS “unexpected”.
  - Phase to phase faults will ALWAYS generate fault current.
  - Phase to ground faults downstream of step-down transformers (PDU) will ALWAYS generate fault current upon the first output-ground fault.
  - Phase to ground faults before downstream distribution ALWAYS generate fault current upon the second fault.
- Bottom line? The UPS will operate safely in all modes, on utility or on battery.

What about faults?

OK, wise guy, what happens if I have a fault while on battery in a 9390 208V UPS with no PDU?

- In this case, there IS a return path, so fault currents will cause UPS to enter 300% current limit for 20 cycles, then trip off.



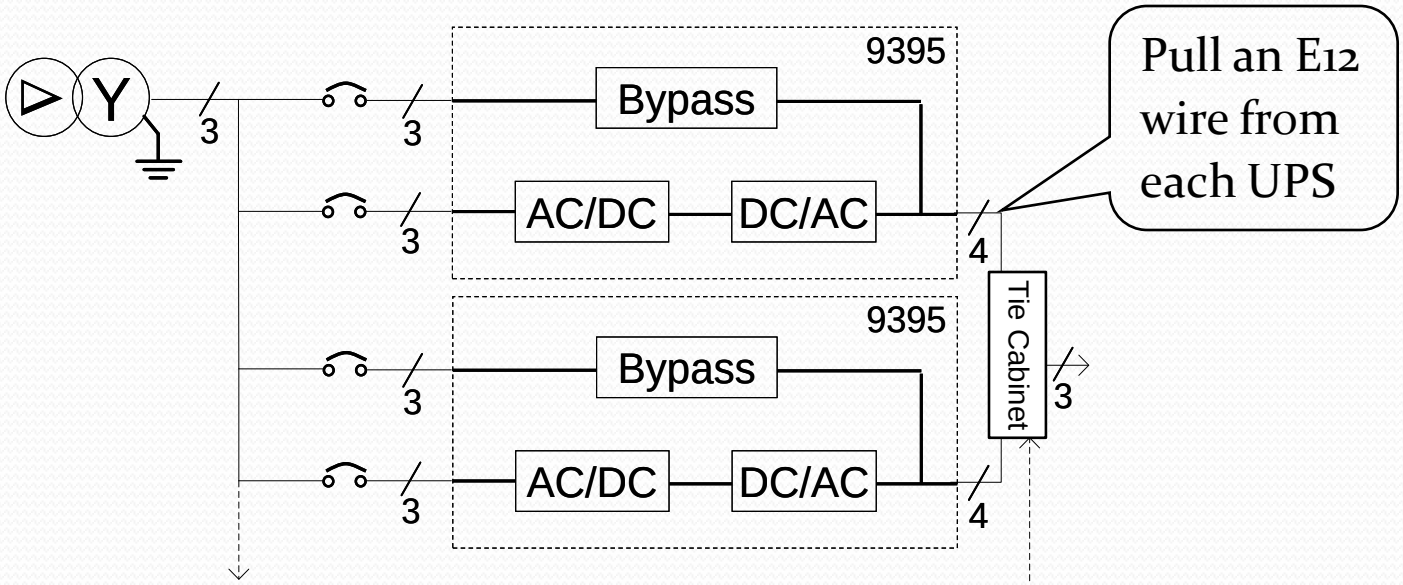
What if I have a parallel system?

- If there are phase to neutral loads connected at the output of the tie cabinet or SBM, the same rule applies: bring in a source neutral to each unit's E12 terminal, and pass that neutral on to the SBM or tie cabinet. Do not bond E12-G in the UPS or at the tie point.

Parallel Systems—Distributed Bypass

If there are NO phase to neutral loads (more typical), we still need a full-rated 4th wire from each UPS E12 to a common tie point in the tie cabinet.

- This may confuse inspectors/installers, but the reason is that we like to have a SINGLE center point reference for the whole parallel system. The impedance from each UPS to its common CP reference needs to be the same. That's why we require a "neutral" wire from each UPS.
- The Neutral bar in the tie cabinet can be bonded to ground. If the inspector objects, we can use NRK kits in each UPS, and remove the N-G bond in the tie cabinet.



UNIT - V

PROTECTION AGAINST OVER VOLTAGES

Causes for Voltage Surge

- Internal Causes : Switching Surges
  - Sudden interruption of a loaded line under short circuit conditions
  - Switching in of an Unloaded transmission line
  - Arcing Grounds
  - Interruption of capacitive currents

Basic Impulse Levels

- 11 KV, 75KV peak impulse strength
- 33 KV, 170KV peak impulse strength
- 132 KV, 650KV peak impulse strength
- 220 KV, 1050KV peak impulse strength
- 400 KV, 1550KV peak impulse strength

GENERATOR FAULTS

- STATOR FAULTS: Ph-Ph FAULTS, Ph-Earth & Inter-turn FAULTS.
- ROTAR FAULTS: ROTAR 1st Earth FAULT &
  ROTAR 2nd Earth FAULT
- OTHER FAULTS:UNDER VOLTAGE, OVER VOLTAGE,
  UNDER-FREQUENCY & OVER-FREQUENCY
  UNBALANCED OPERATING CONDITIONS
  LOSS OF EXCITATION
- LOSS OF INPUT TO TURBINE
- LOSS OF SYNCHRONISM

TRANSFORMER FAULTS

- INSULATION FAILURE: **INSULATING MATERIAL, OIL DI-ELECTRIC STRENGTH DETEREORATION – GAS ACTUATING Buchholzrelay.**
- **Ph – Ph FAULTS, Ph – Earth FAULTS & INTER TURN FAULTS: DIFFERENTIAL PROTECTION ,O/C & E/F RELAYS.**
- **EXTERNAL FAULTS BEING FED THROUGH THE TRANSFORMER:O/C & E/F RELAYS.**

INSTRUMENT TRANSFORMERS

- Instrument Transformers (C.Ts & P.Ts) are required to handle high voltages & high currents within safe limits of operating personnel and equipment for metering and protection.
- Current Transformers:high magnitude of current can be reduced to either 1 Amp or 5Amps.
- Voltage Transformers:Electro magnetic PT s & capacitors voltage transformers.

TYPES OF RELAYS

- ELECTRO MAGNETIC: Min time of operation 100 ms
- STATIC RELAYS:
- MICROPROCESSOR BASED PROGRAMABLE RELAYS:40–60 ms
- NUMERICAL RELAYS: 20 – 30 ms

TYPES OF RELAYS

- OVER CURRENT RELAYS FOR NORMAL OVER LOADS & Ph-Ph FAULTS.
- EARTH FAULT RELAYS FOR SENSING Ph-Earth FAULTS.
- DISTANCE RELAYS:REACTANCE RELAYS,IMPEDANCE AND MHO RELAYS,R-X DIAGRAM.
- TRANSFORMER DIFFERENTIAL RELAYS, buchholzrelays.

APPLICATION OF CTs & PTs

- METERING:
  AMMETER CT CONNECTION
  VOLT METER PT CONNECTION
  WATT METER & VAR METERS BOTH CT & PT CONNECTION
  FREQUENCY METER – PT CONNECTION
- RELAYS: OVER CURRENT CT CONNECTION
  EARTH FAULT CT CONNECTION
- DISTANCE RELAYS(X,Z,MHO)- BOTH CT & PT CONNECTIONS

ESSENTIAL REQUIREMENTS OF RELAYS

- SENSITIVITY
- SELECTIVITY
- SPEED
- STABILITY
- RELIABILITY

Lightning Protection

Facts about Lightning

- A strike can average 100 million volts of electricity
- Current of up to 100,000 amperes
- Can generate 54,000 ^{o}F
- Lightning strikes somewhere on the Earth every second
- Kills 100 US residents per year

Lightning Doesn't Go Straight Down

Use The Five Second Rule

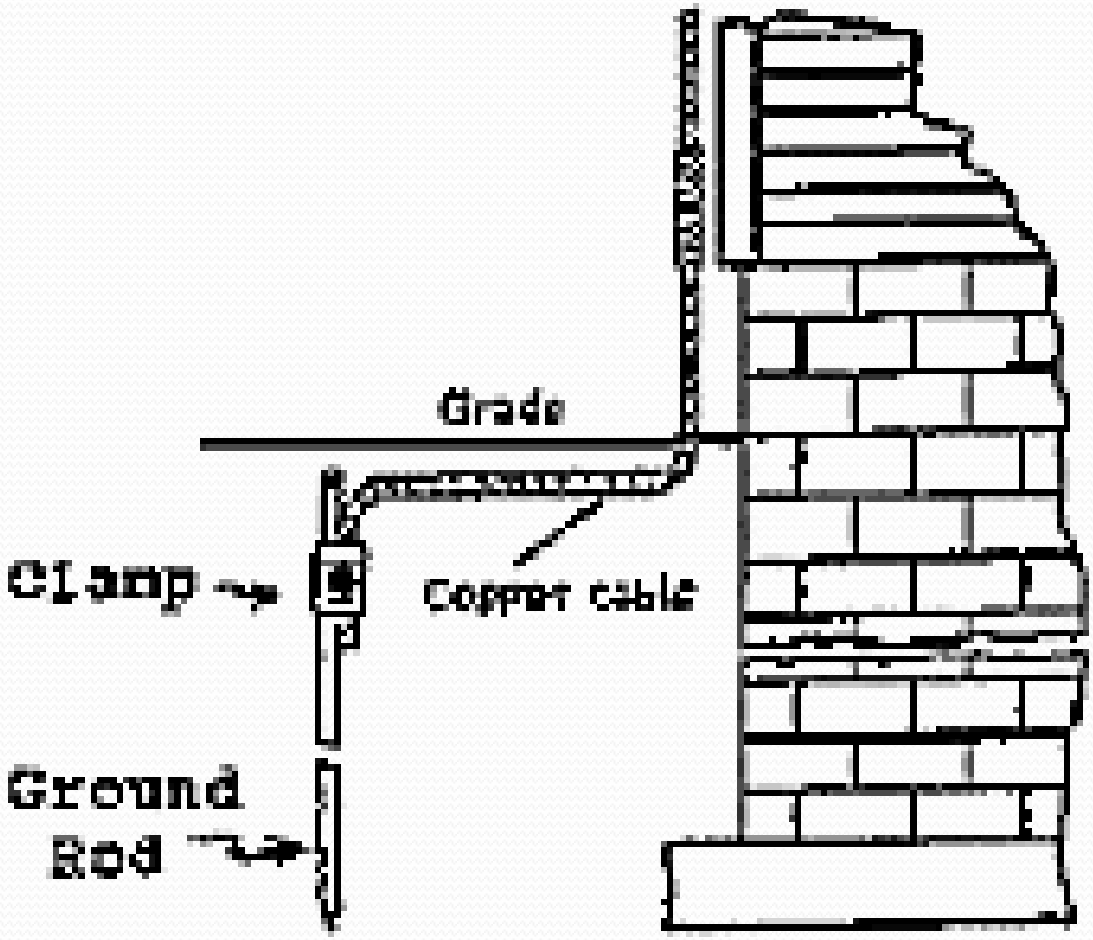
- Light travels at about 186,291 ***miles***/second
- Sound travels at only 1,088 ***feet***/second

- You will see the flash of lightning almost immediately
  - 5280/1088= 4.9
- About 5 seconds for sound to travel 1 mile

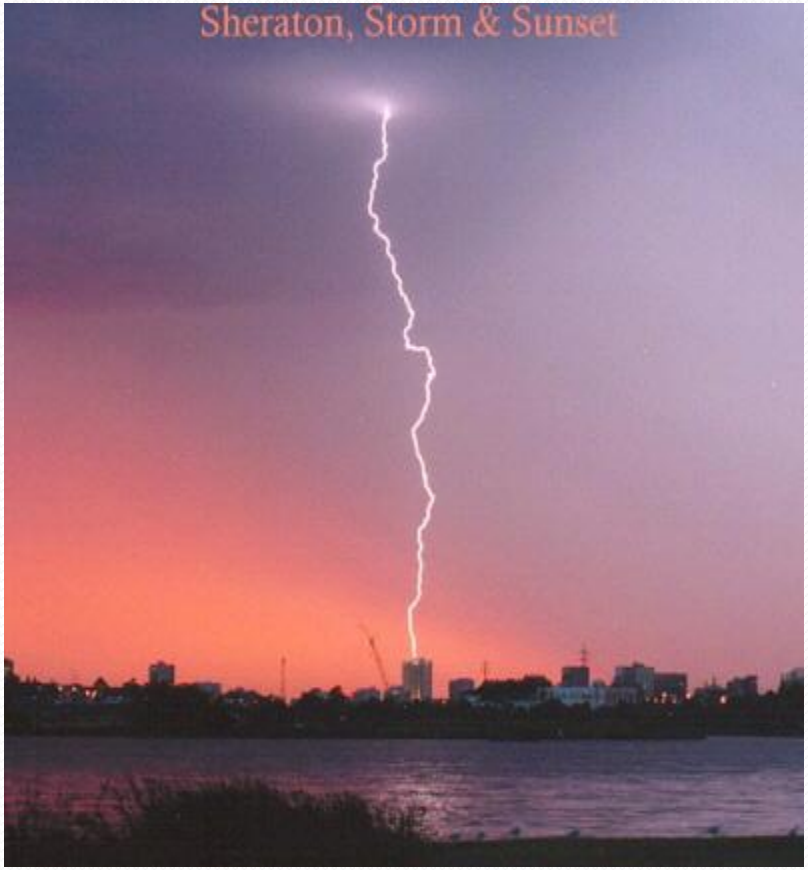
Four Main Features of Lightning Protection

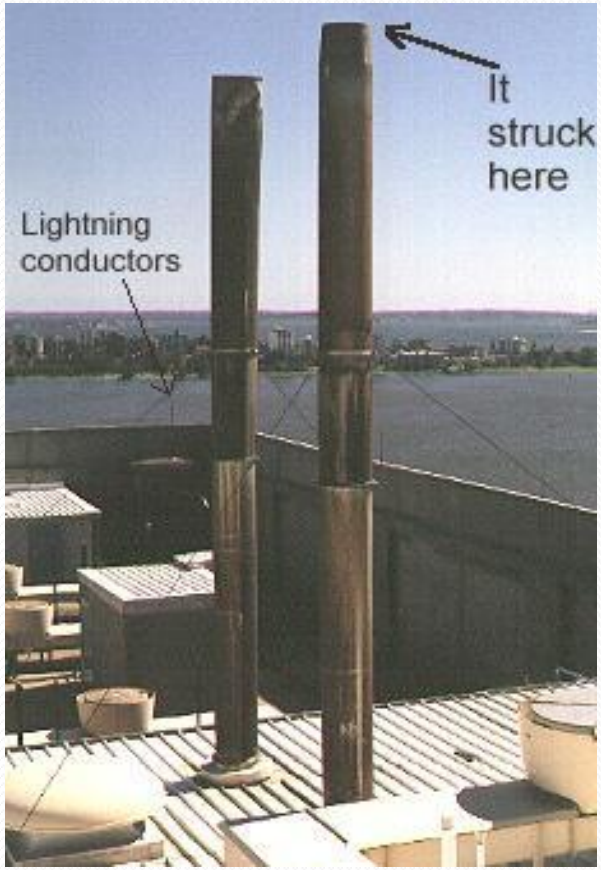
- 1) Air terminal
- 2) Conductors
- 3) Ground termination
- 4) Surge protection

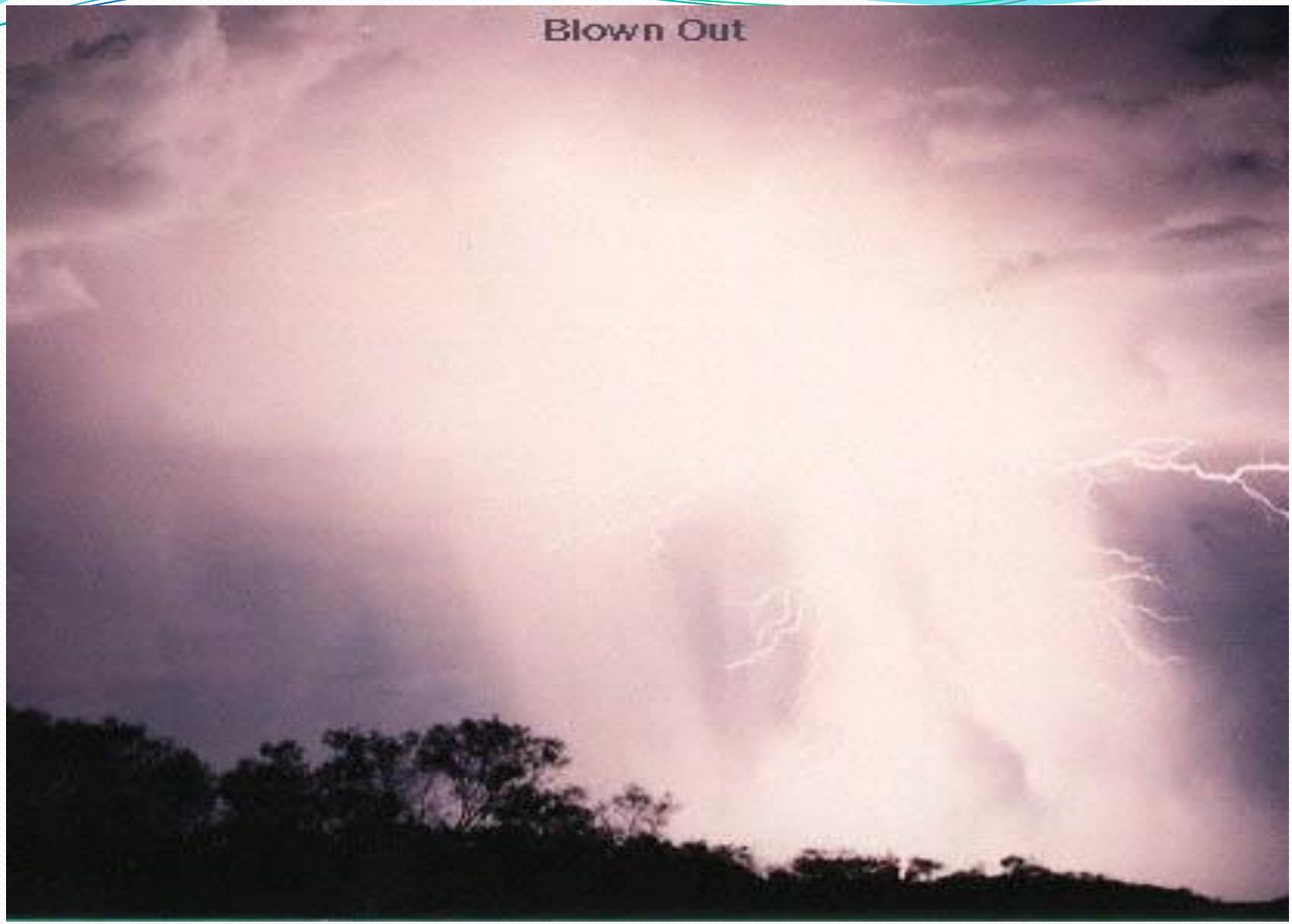
Grounding Rod



Surge Protection Is A Must






Blown Out

Effects Of Lightning