EEE3112 Electrical Engineering Practice

Lecture 1

1. Revisit Course Outline

1. Occupational health and Safety: Risk definitions: hazard, danger, damage, risk, Accidents, Risk perception, Hazard control and design
2. Ohm's law: Insulators and conductors, Health effects, AC and DC circuits
3. Branch circuits: Wiring methods/plugs and receptacles, polarity, Grounding
4. Circuit and equipment testing: Testing branch circuits, Receptacles, Extension cords, Plug and cord- connected equipment, Voltage detectors
5. Ground Fault Circuit Interrupters (GFCI's): Theory, GFCI Configurations, Applications
6. Flammable/Combustible Materials (Hazardous Locations): Combustion and explosions, Electrical ignition sources, controlling ignition hazards.
7. Electrical lockout/tag out: Definitions and standards, Permit systems Need for hazardous energy control, Written program, Training. Standards/Common electrical deficiencies.

8. Electrical Drawing: Graphical symbols. Various types of diagram; examples from electronic and power equipment, and power systems. Views and sections of some items of electrical equipment.

Note: Topics 1 and 2 covered in EEE3352

ASSIGNMENT 1

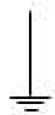
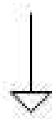
1. Write brief notes on what you understand about occupational health and safety

2. What are conductors and insulators?

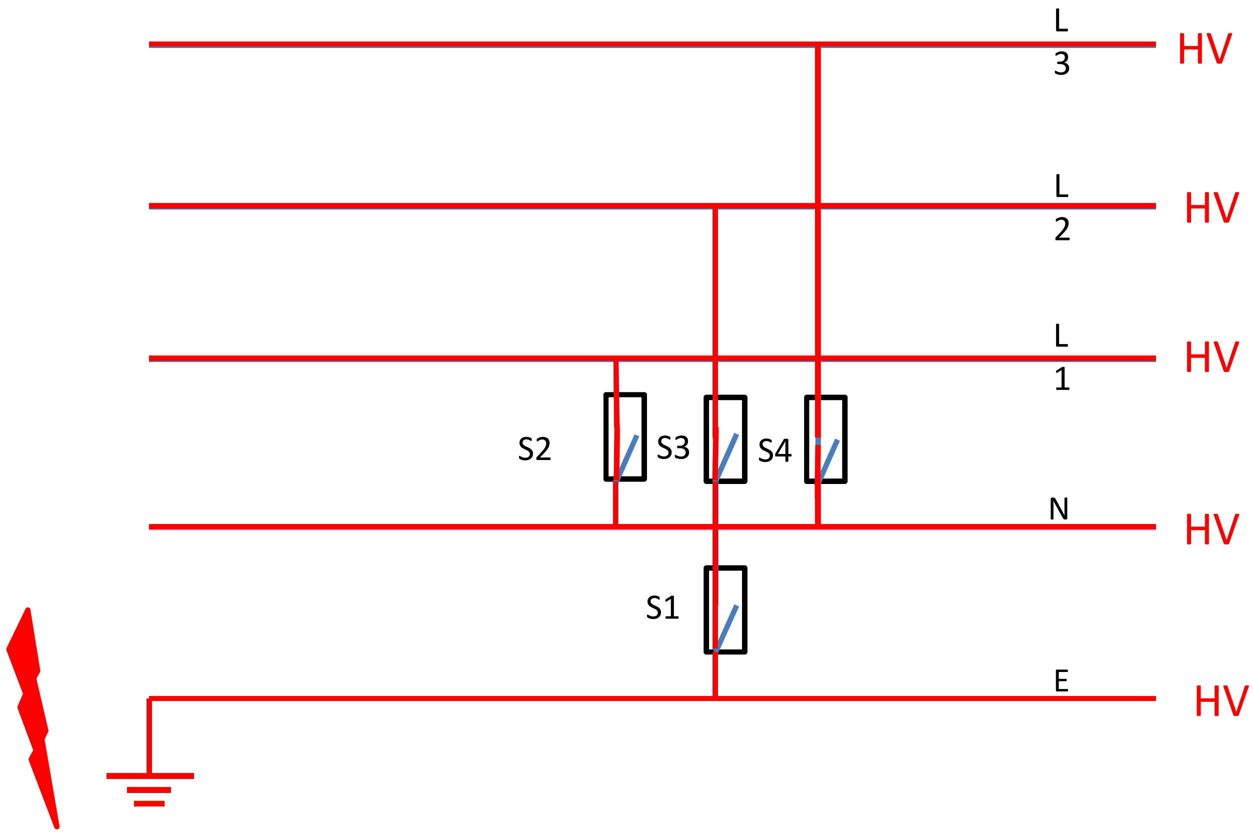
3. What are the health effects related to AC and DC circuits?

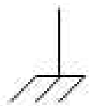
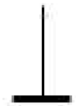
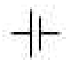
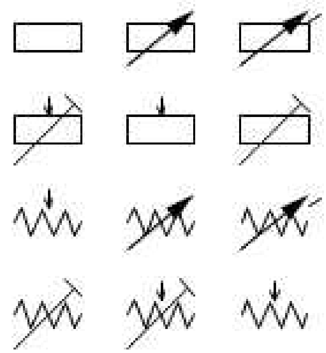
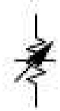
2. Electrical Drawings

The following are some basic electrical symbols.

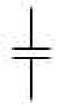
Name	Electrical Symbol	Alternate Symbol	Function Description
ground			A connection to earth. Used for zero potential reference and electrical shock protection.
equipotentiality			Equipotentiality is a symbol to identify parts that have the same voltage (i.e. same electrical potential i.e. equipotential). Since equipotential surfaces all have the same voltage, you won't get shocked if you touch two such surfaces (unless of course you are also touching some OTHER part that has a different potential from the first two).

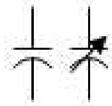
SPD Operation



chassis			Connected to the chassis of the circuit.
battery			Supplies electrical energy. A battery is more than one cell. It generates constant voltage and represents a battery in an equipment package.
resister			A resistor restricts the flow of current, for example to limit the current passing through an LED. A resistor is used with a capacitor in a timing circuit.
attenuator			A box with input and control logic on one side, and output on the other.

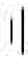
capacitor





A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.

accumulator



Accumulators are designed to increase or relieve pressure in the system.

antenna

A antenna is a radio antenna that can be made of a simple wire, with a center-fed driven element.

loop antenna

A loop antenna is a radio antenna consisting of a loop (or loops) of wire, tubing, or other electrical conductor with its ends connected to a balanced transmission line.

crystal

circuit breaker

fuse

ideal source

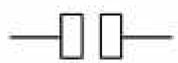
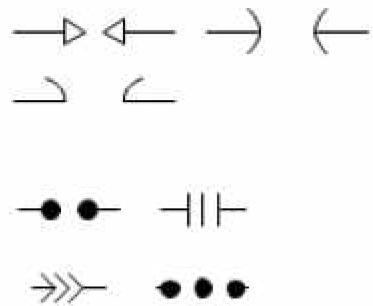
generic component

transducer

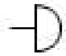
A crystal oscillator uses the mechanical resonance of a vibrating crystal of piezoelectric material to create an electrical signal with a very precise frequency.

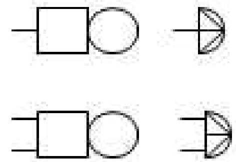
A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit.

A type of sacrificial overcurrent protection device. Represents low voltage and power fuses.

inductor			A coil of wire which creates a magnetic field when current passes through it. It may have an iron core inside the coil. It can be used as a transducer converting electrical energy to mechanical energy by pulling on something. It is a passive two-terminal electrical component used to store energy in a magnetic field.
surge protectors			Surge protectors protect your electronics from power surges in your electrical system.

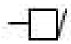
bell





The electric bell is found in a normal house doorbell, and when activated it makes a ringing sound.

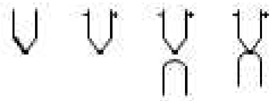
buzzer



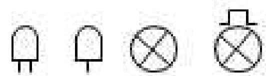
An electrical buzzer is similar to the bell, but instead of a single tone or bell sound it makes a constant buzz noise.

thermal element

thermocouple

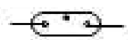


lamp



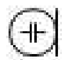
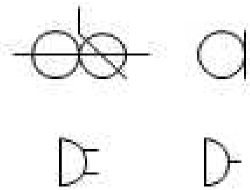
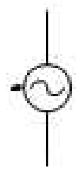
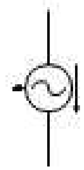
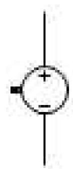
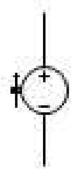
A transducer which converts electrical energy to light, which is used for a lamp providing illumination, for example a car headlamp or torch bulb.

fluorescent lamp



speaker

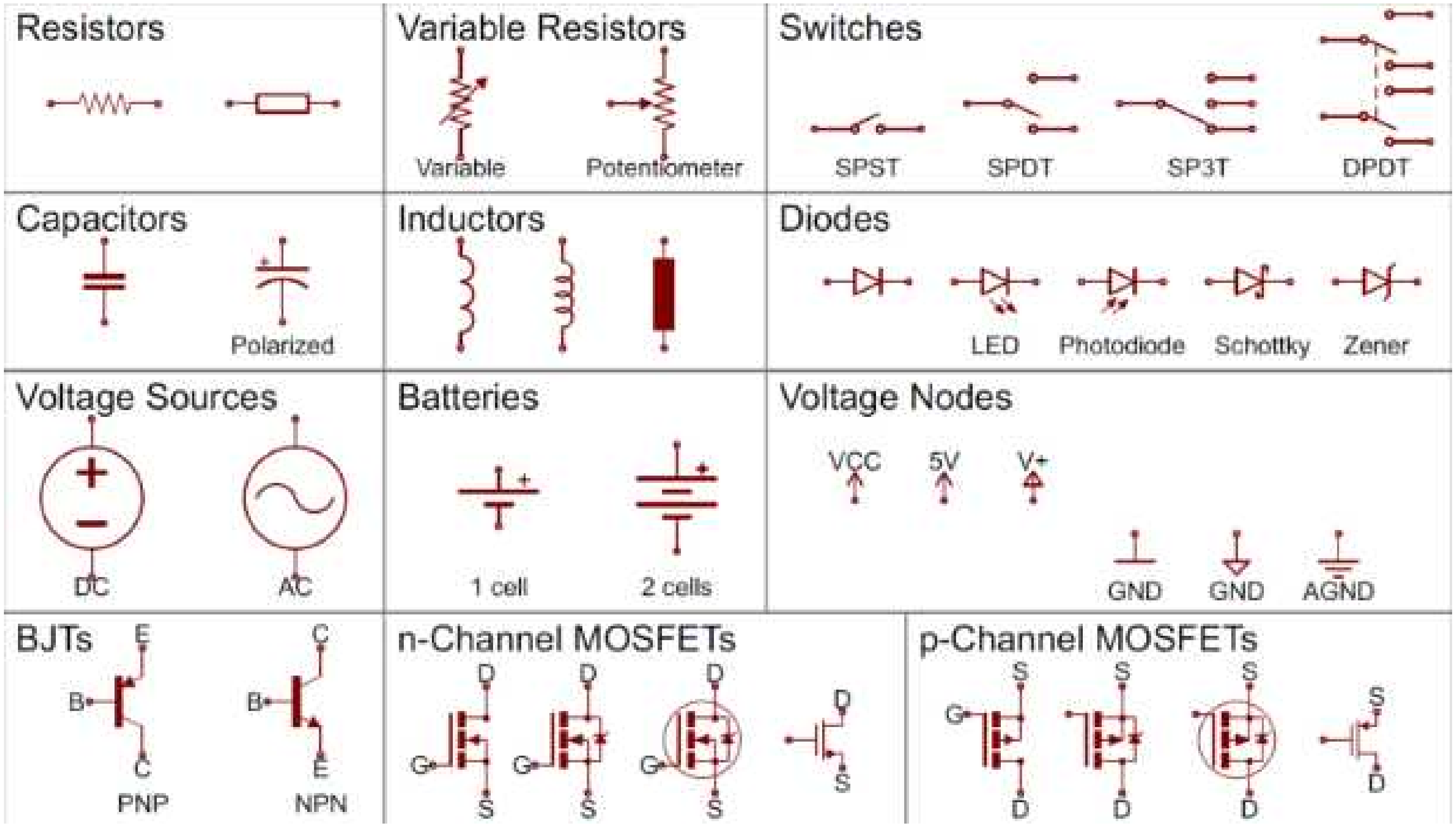
A speaker can take digital input and turn it into analogue sound waves. One of the most important parts of a wide range of electrical products like TVs and telephones.

microphone			
oscillator			Produces a repetitive electronic signal, often a sine wave or a square wave.
AC source			Alternating Current, continually change direction.
DC source			Direct Current, always flow in one direction.

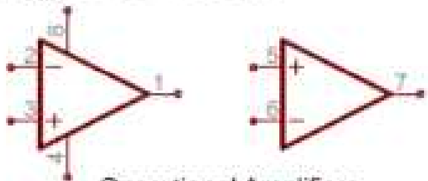
- **NOTES:**
- Each electrical component may have numerous possible representations.
- The electrical symbols can vary from country to country nowadays, but are to a large extent internationally standardized.
- Some electrical symbols become virtually extinct with the development of new technologies.
- In cases where there is more than one common electrical symbol, alternative representations are given.

3. Reading Electrical Drawings

- Schematics are our map to designing, building, and troubleshooting circuits.
- Understanding how to read and follow schematics is an important skill for any engineer.
- This lecture should turn you into a fully literate schematic reader!
- The most commonly used graphical symbols are shown in the following slides.

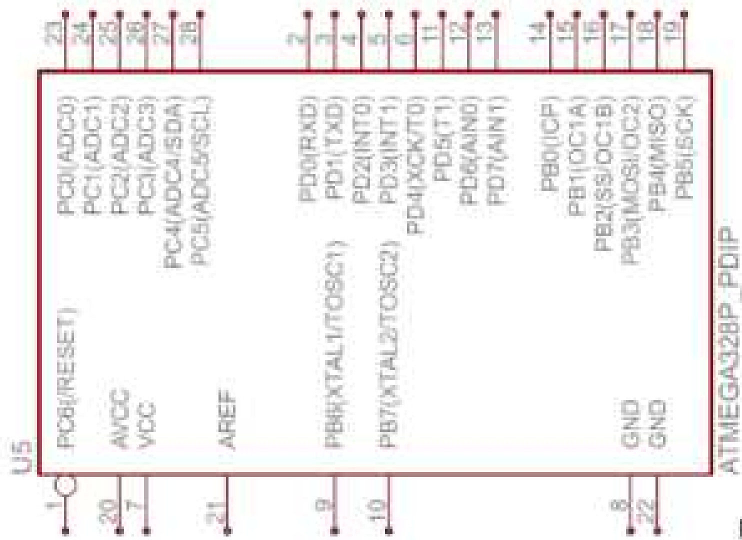

Resistors
Variable Resistors
Variable
Potentiometer
Switches
SPST
SPDT
SP3T
DPDT
Capacitors
Polarized
Inductors
Diodes
LED
Photodiode
Schottky
Zener
Voltage Sources
DC
AC
Batteries
1 cell
2 cells
Voltage Nodes
VCC
5V
V+
GND
GND
AGND
BJTs
PNP
NPN
n-Channel MOSFETs
p-Channel MOSFETs

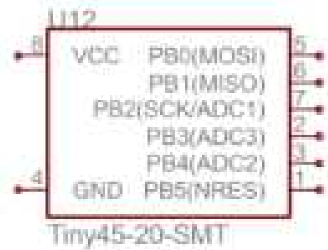
Integrated Circuits



Operational Amplifiers

Voltage Regulators

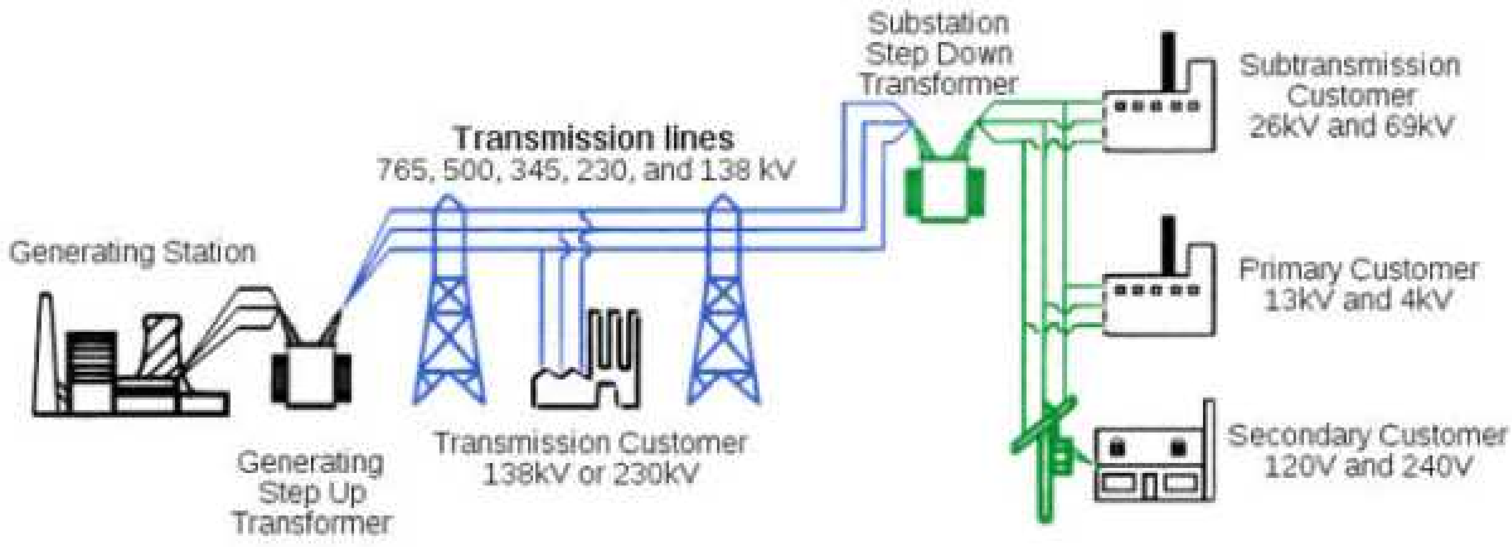




Microcontrollers

4. Electric power transmission

- Electric power transmission is the bulk transfer of electrical energy, a process in the delivery of electricity to consumers.
- A power transmission network typically connects power plants to multiple substations near a populated area.
- The wiring from substations to customers is referred to as electricity distribution, following the historic business model separating the wholesale electricity transmission business from distributors who deliver the electricity to the homes.



- Electric power transmission allows distant energy sources (such as hydroelectric power plants) to be connected to consumers in population centres, and may allow exploitation of low-grade fuel resources such as coal that would otherwise be too costly to transport to generating facilities.

Transmission line in perspective.

Hydroelectric Station

Steam Electric Station

4.1 Usage of area under overhead power lines

- Use of the area below an overhead line is restricted because objects must not come too close to the energized conductors.

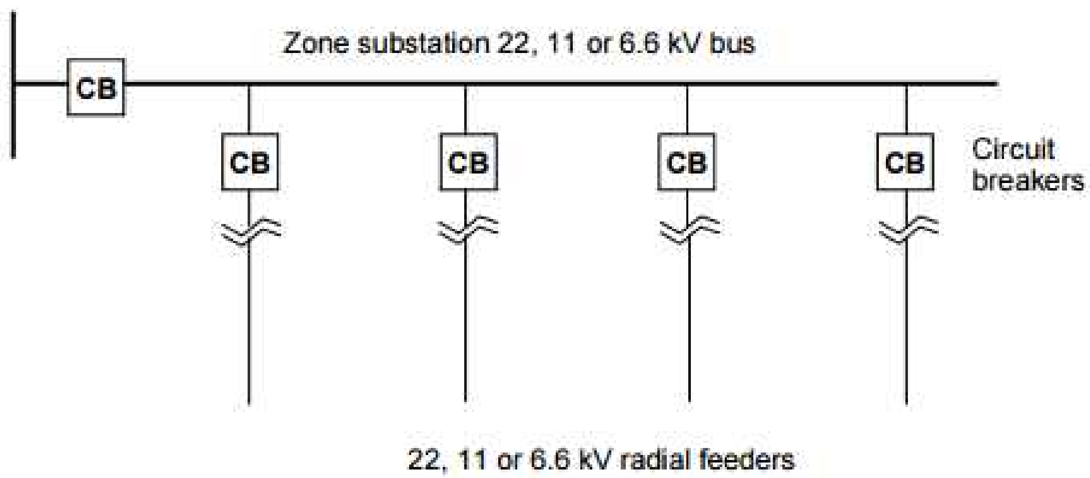
- Radio reception can be impaired under a power line, due both to shielding of a receiver antenna by the overhead conductors, and by partial discharge at insulators and sharp points of the conductors which creates radio noise.

- In the area surrounding overhead lines it is dangerous to risk interference; e.g. flying kites or balloons, using ladders or operating machinery.

- Overhead distribution and transmission lines near airfields are often marked on maps, and the lines themselves marked with conspicuous plastic reflectors, to warn pilots of the presence of conductors.

4.2 Types of distribution feeder systems

- Many distribution systems operate using a ‘radial feeder’ system. A typical radial feeder system is shown schematically below.



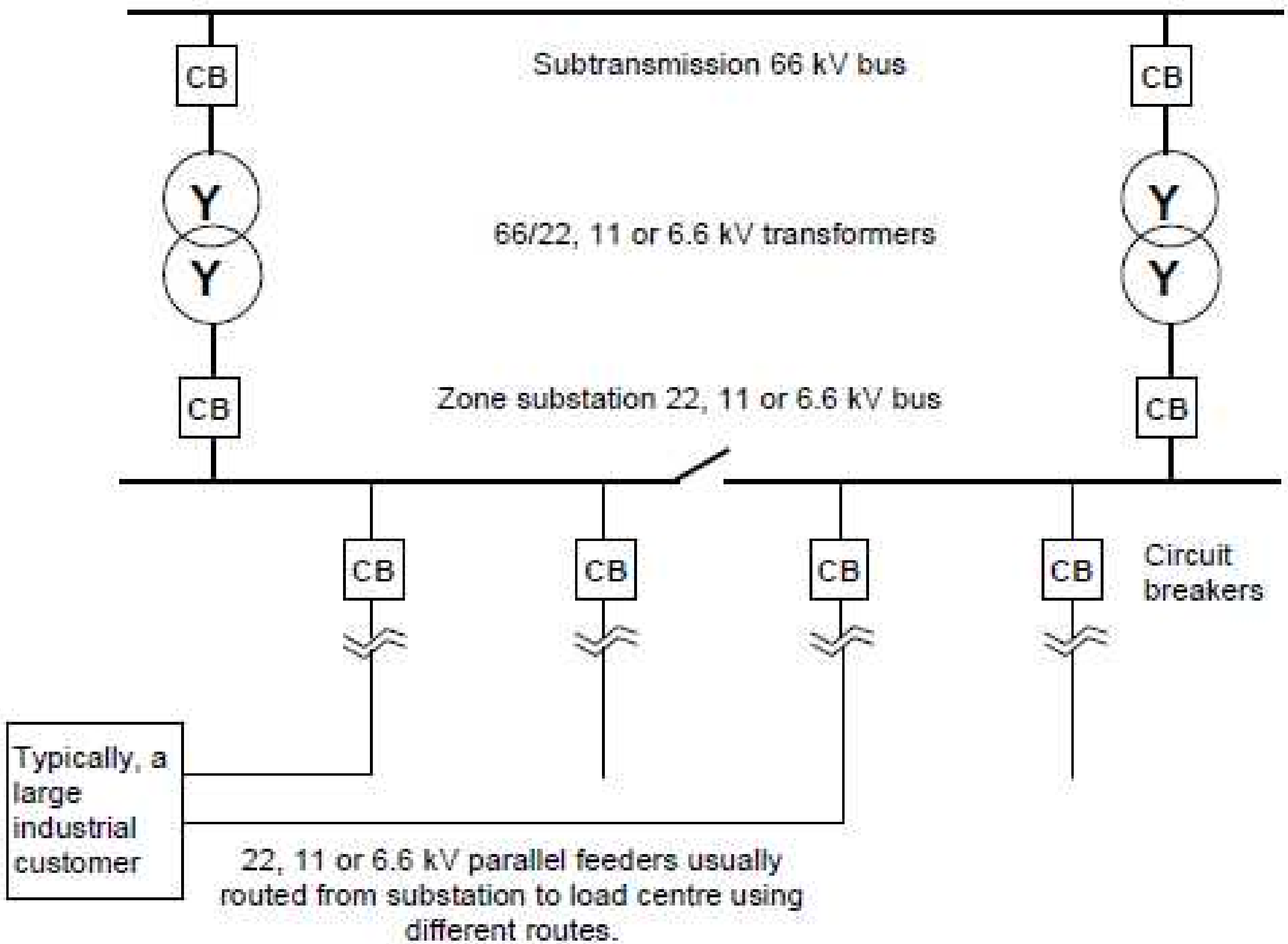
- Radial feeders are the simplest and least expensive, both to construct and for their protection system.
- This advantage however is offset by the difficulty of maintaining supply in the event of a fault occurring in the feeder.
- A fault would result in the loss of supply to a number of customers until the fault is located and cleared.
- The next level of reliability is given by a ‘parallel feeder’ system.

4.3 Parallel feeders

- A greater level of reliability at a higher cost is achieved with a parallel feeder. A typical parallel feeder system is shown schematically on the following slide.

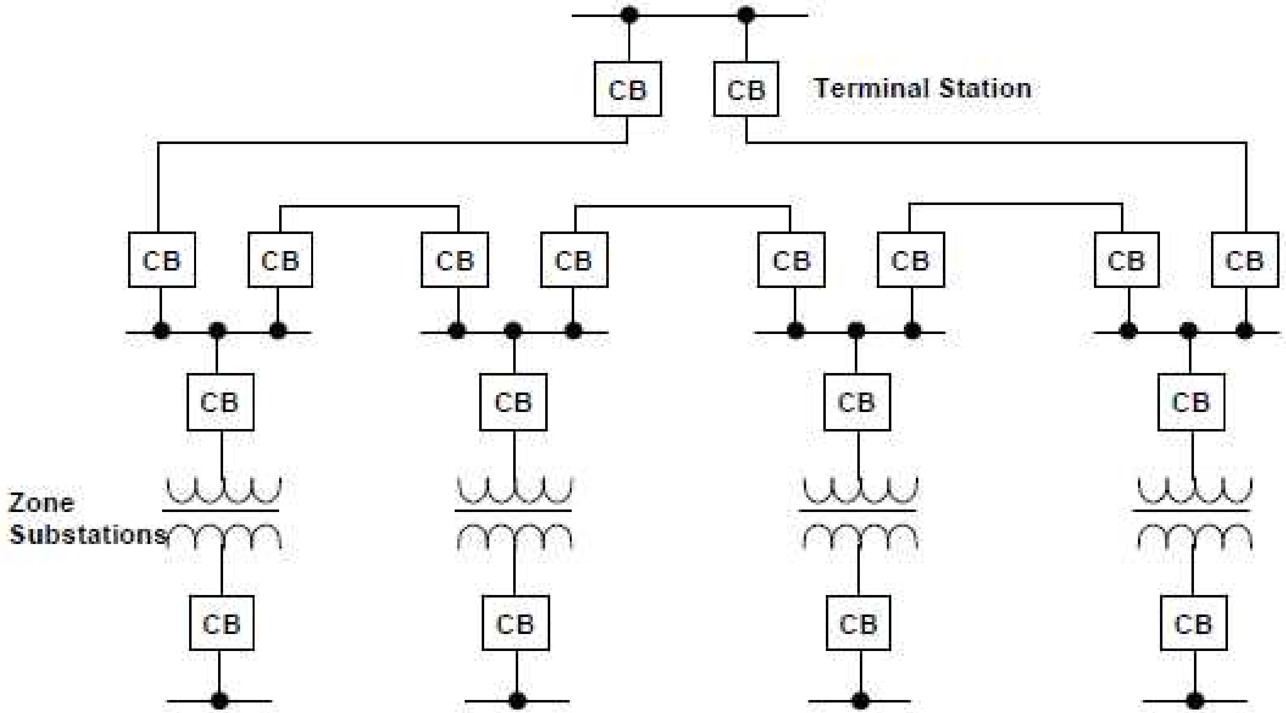
- In the event of a line fault only one of the feeder sets of cables will be affected, thus allowing the remaining parallel feeder to continue to supply the load.

- Parallel feeders are more common in urban areas or for feeders to large single customers, where load shedding in an emergency may be possible.


Subtransmission 66 kV bus
CB
CB
Y
Y
Y
Y
66/22, 11 or 6.6 kV transformers
CB
CB
Zone substation 22, 11 or 6.6 kV bus
CB
CB
CB
CB
Circuit breakers
Typically, a large industrial customer
22, 11 or 6.6 kV parallel feeders usually routed from substation to load centre using different routes.

4.4 Ring main

- A similar level of system reliability to that of the parallel arrangement can be achieved by using ‘ring main’ feeders.
- This usually results from the growth of load supplied by a parallel feeder where the cabling has been installed along different routes.
- These are most common in urban and industrial environments.
- Whilst the start and finish ends of the ring are at the same location, power is delivered by both pathways of the ring into substations located around the ring.



A ring main feeder system

- Should a fault occur on a feeder cable at any point around the ring the faulty section may be isolated by the operation of the protecting circuit breakers, at the same time maintaining supply to all substations on the ring.

- In typical urban/suburban ring-main arrangements, the open ring is operated manually and loss of supply restored by manual switching.

- Current practice is to use ‘distribution automation’, where operation and supply restoration in the feeder rings is done automatically by centrally-controlled supervisory systems.

- This gives the advantages of ring main systems as line voltage drops are reduced at the various load Substations there is a ‘firm’ supply (ie an alternative path is available if the primary one fails) to each load substation.

4.5 Meshed systems

- In transmission and sub-transmission systems, usually parallel, ring or interconnected ('mesh') systems are used.
- This ensures that alternative supply can be made to customers in the event of failure of a transmission line or element.
- The extra expense can be justified because of the much greater load and number of customers that are affected by failure of lines at transmission or sub-transmission levels.
- The general rule is that where large loads or numbers of customers are involved, then some form of standby, in the form of deliberate redundancy, is built into the network design, through the use of parallel, meshed or ring type feeders.

- Only in outer rural areas would one consider using only radial supply at a sub-transmission level.
- On the other hand, simple radial supply is almost universally used for low voltage (400V) feeders, even in urban areas, because they supply relatively few customers.

ASSIGNMENT 2

1. List the voltage levels used in the various stages of transmission and distribution electric power system in Zambia.
2. List the main sections of a power system, starting with the generators and ending with the customer's load?

3. State where one would use each of the following types of feeders. Give reasons in each case.
   a. Radial feeders
   b. Parallel feeders
   c. Ring feeders
   d. Meshed feeders
4. How can the cost of the higher-level feeder systems be justified?

ASSIGNMENT DUE IN A WEEK

5. Overhead and Underground Power Systems

- Initial overhead line construction is less expensive than underground cabling for the same kVA load.
- In rural or semi-rural areas, the sheer cost of underground cabling would make it impossible for customers to be able to afford the cost of supply.
- The down side is that overhead lines operate under continual mechanical stress with exposure to varying climatic conditions.
- This results in progressive deterioration in time as a result of corrosion, mechanical wear and fatigue, timber rot, etc.

- All components must be periodically inspected and replaced as required. They are exposed to environmental impacts such as storms, lightning, wind-blown debris and traffic impact (of poles) which means overhead systems are rarely as reliable as underground ones.

- The greater spacing of overhead line conductors generally results in higher system inductance than for a cable system.

- This means an overhead line has a greater voltage drop than an underground cable of equal current-carrying capacity and hence cannot supply power over as long a distance as the underground equivalent, particularly for lower voltage distribution systems.

- Even though poles are considered unsightly in urban locations, the capacity of an overhead feeder can be readily increased by replacing it with larger conductors and/or increasing the voltage insulation/operating level.

6. Three Phase, Single Phase and Single Wire Earth Return Systems

- By far the majority of customers have electricity supplied to their homes, offices, factories, etc. as a three phase and/or single phase supply at voltages of 400 volts and/or 230 volts.

- Most houses are supplied at 230 volt single phase, as this is cheapest for light loads, involving only two wires.

- Medium sized ‘business’ customers (ie, factories, shops) are normally supplied at 400 volt three-phase.

- This involves running four wires into the customer and is still cost effective in urban areas because the street supply is always three phase.

- The low voltage consists of three 230 Volt active phases and one ‘neutral’. The neutrals are then connected to the customers load using the MEN system of earthing.

- This provides a low resistance connection to earth providing protection to both the customers and the supply system in the event of faults.

- Large customers cannot be supplied economically at 400/230 volts because of the high cost of providing all the cabling that would be required.

- Instead, such customers (eg mines, large industrial sites, large commercial centres) are usually supplied at a high voltage instead of the conventional 400/230 Volts.

- In the above case the customer would usually own (or lease) the power transformer or transformers needed to reduce the high voltage supply, and in return the customer would have a lower tariff for energy consumed.

- Single wire earth return (SWER) or single wire ground return is a single-wire transmission line for supplying single-phase electrical power from an electrical grid to remote areas at low cost.

- It is principally used for rural electrification, but also finds use for larger isolated loads such as water pumps, and light rail.

- Single wire earth return is also used for HVDC over submarine power cables.

6.1 SWER

- SWER is a choice for a distribution system when conventional return current wiring would cost more than SWER's isolation transformers and small power losses.

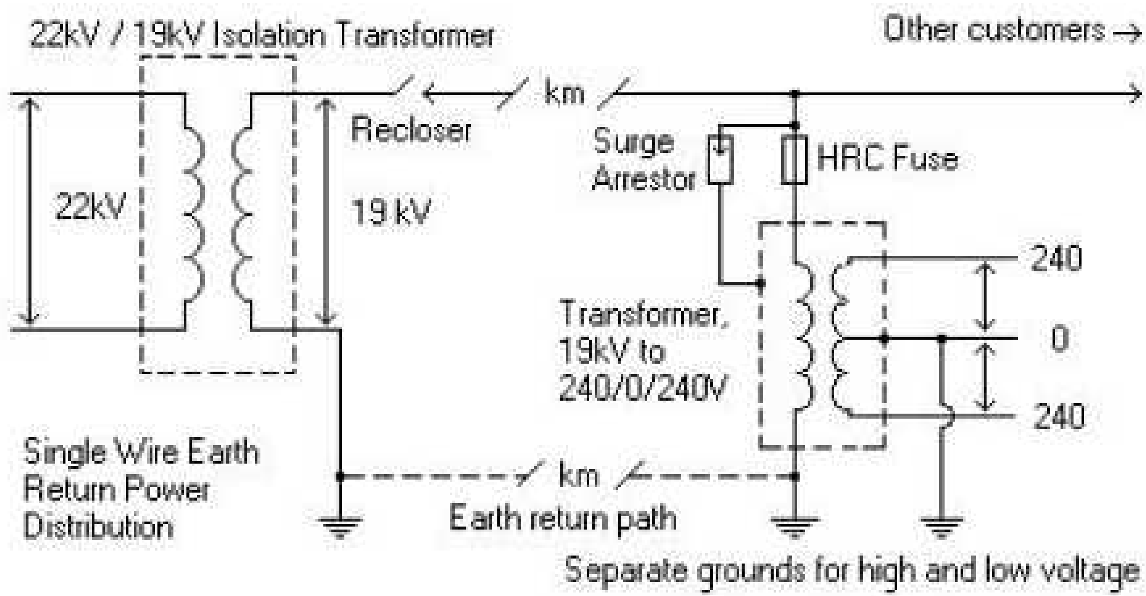
- Power engineers experienced with both SWER and conventional power lines rate SWER as equally safe, more reliable, less costly, but with slightly lower efficiency than conventional lines.

- SWER uses conventional 50Hz or 60Hz AC power, and is therefore much less expensive. Conventional low frequency 50Hz or 60Hz power is supplied to the SWER line by an isolating transformer of up to 300 kVA.

- This transformer isolates the grid from ground or earth, and changes the grid voltage (typically 22 kilovolts line to line) to the SWER voltage (typically 12.7 or 19.1 kilovolts line to earth).

SWER line

- The SWER line is a single conductor that may stretch for tens or even hundreds of kilometres, visiting a number of termination points.
- At each termination point, such as a customer's premises, current flows from the line, through the primary coil of a step-down transformer, to earth through an earth stake.
- From the earth stake, the current eventually finds its way back to the main step-down transformer at the head of the line, completing the circuit. SWER is therefore a practical example of a phantom loop.
- SWER burns up grounding poles or may fail to reset breakers in areas with high resistance soil.



- In Australia, locations with very dry soils need the grounding poles to be extra deep.
- Experience in Alaska shows that SWER needs to be grounded below permafrost, which is high-resistance.

- The secondary winding of the local transformer will supply the customer with either single ended single phase (N-0) or split phase (N-0-N) power in the region’s standard appliance voltages, with the 0 volt line connected to a safety earth that does not normally carry an operating current.

- A large SWER line may feed as many as 80 distribution transformers.

- The transformers are usually rated at 5 kVA, 10 kVA and 25 kVA. The load densities are usually below 0.5 kVA per kilometer (0.8 kVA per mile) of line.

6.2 Characteristics

- SWER violates common wisdom about electrical safety, because it lacks a traditional metallic return to a neutral shared by the generator.
- SWER's safety is instead assured because transformers isolate the ground from both the generator and user.
- However, certain groups claim that stray voltages from SWER can injure livestock.
- Grounding is critical because of the significant currents on the order of 8 amperes that flow through the ground near the earth points, so a good-quality earth connection is needed to prevent risk of electric shock due to earth potential rise near this point.

- A good earth connection is normally a 6 m stake of copper-clad steel driven vertically into the ground, and bonded to the transformer earth and tank. A good ground resistance is 5–10 ohms.

- SWER systems are designed to limit the voltage in the earth to 20 volts per meter to avoid shocking people and animals that might be in the area.

- Other standard features include automatic reclosing circuit breakers (reclosers). Most faults (over-current) are transient. Since the network is rural, most of these faults will be cleared by the recloser.

- Each service site needs a rewirable drop out fuse for protection and switching of the transformer. The transformer secondary should also be protected by a standard high-rupture capacity (HRC) fuse or low voltage circuit breaker. A surge arrestor (spark gap) on the high voltage side is common, especially in lightning-prone areas

End of Lecture!