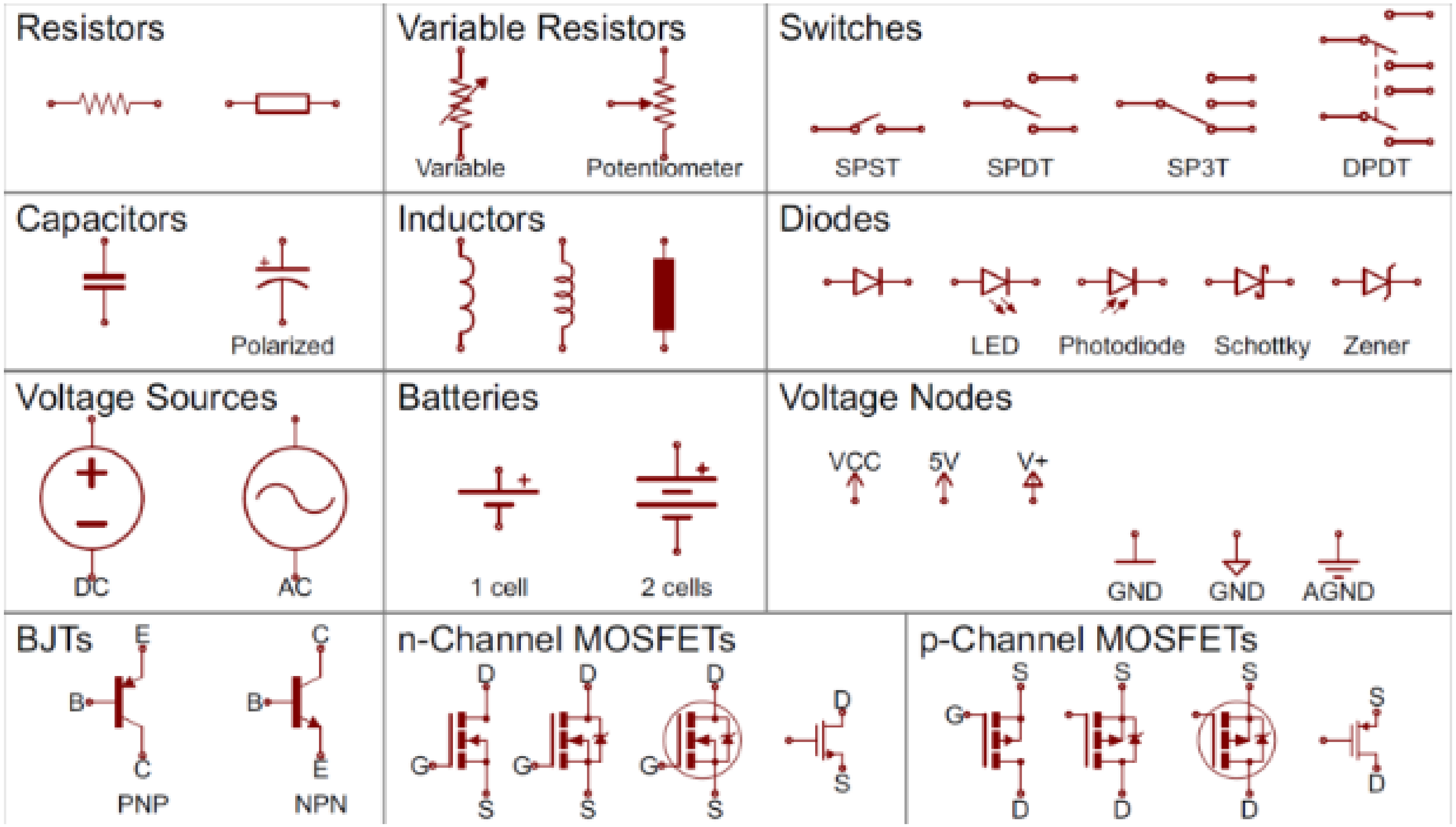
EEE 3112 Electrical Engineering Practice

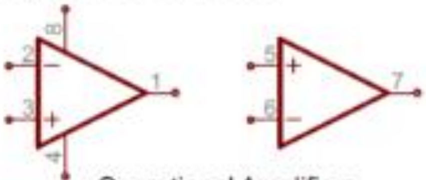
Lecture 2: Electrical Drawings

1. Reading Electrical Drawings

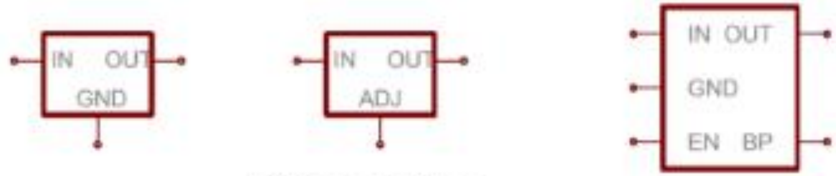
- Schematics are our map to designing, building, and troubleshooting circuits.
- Understanding how to read and follow schematics is an important skill for any engineer.
- This lecture should turn you into a fully literate schematic reader!
- The most commonly used graphical symbols are shown in the following 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
E
B
C
PNP
C
B
E
NPN
n-Channel MOSFETs
D
G
S
p-Channel MOSFETs
S
G
D

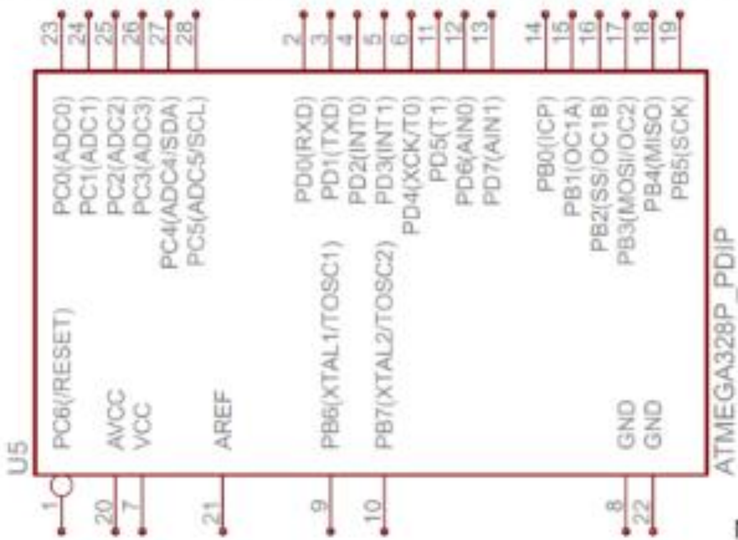
Integrated Circuits

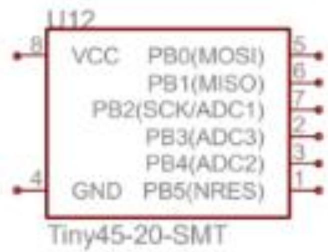


Operational Amplifiers



Voltage Regulators





Microcontrollers

- **NOTES:**

- Each electrical component may have numerous possible representations.

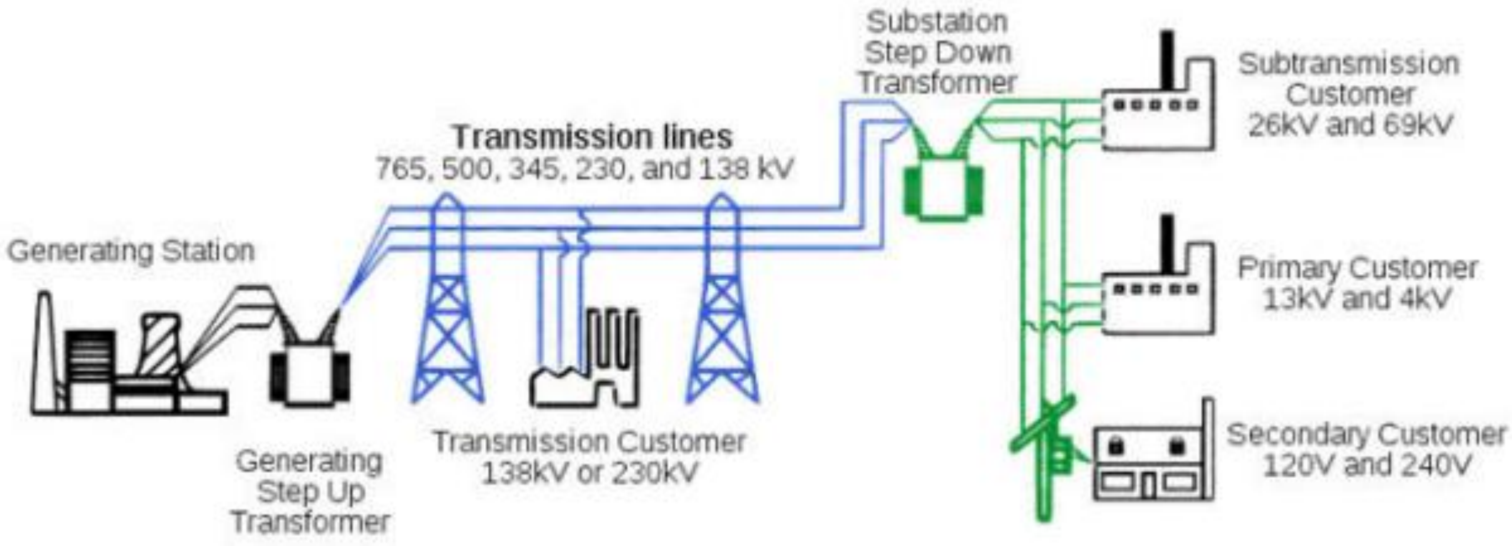
- The electrical symbols can vary from country to country nowadays, but are to a large extent internationally standardized.

- 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.

2. 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

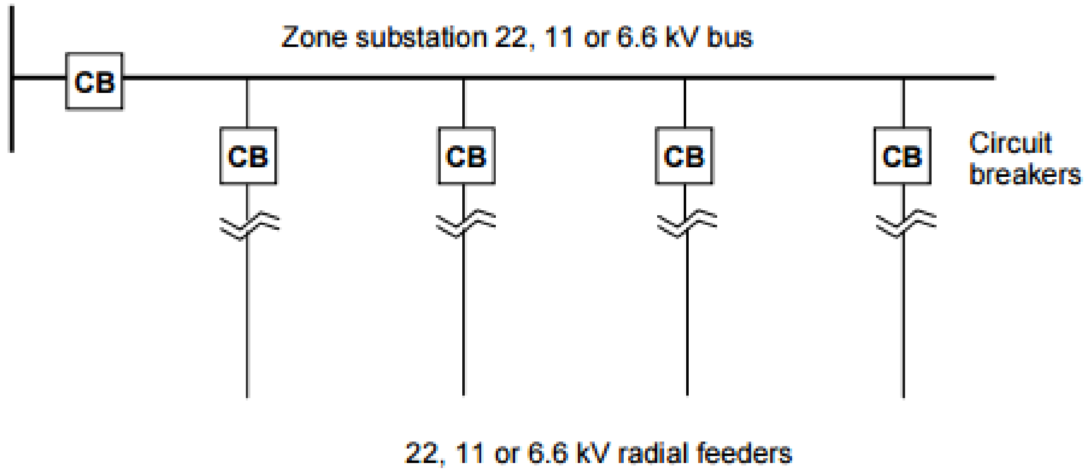
Steam Electric Station

2.1 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.

2.2 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.

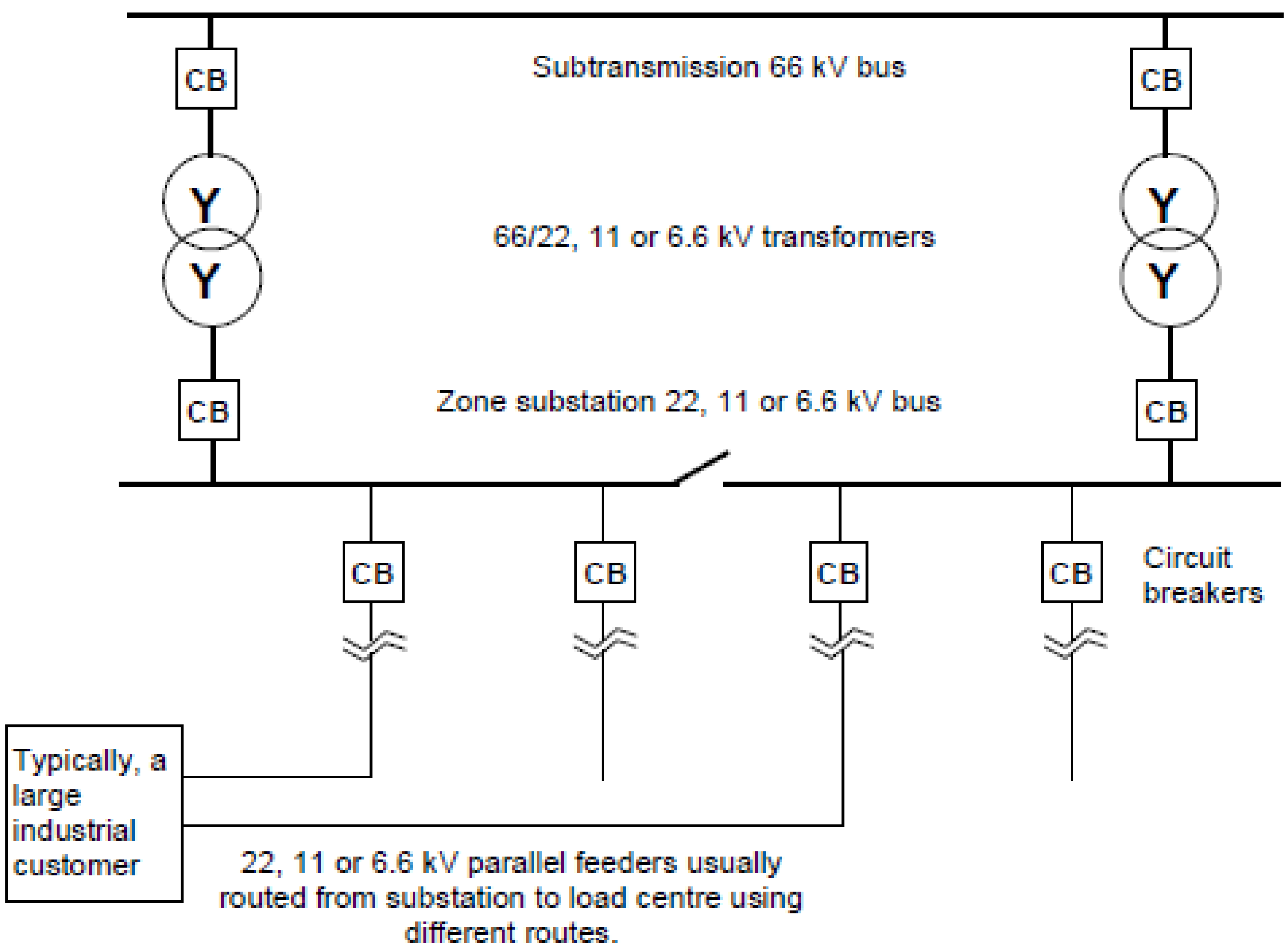
- The next level of reliability is given by a ‘parallel feeder’ system.

2.3 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.


CB
Subtransmission 66 kV bus
CB
Y
Y
66/22, 11 or 6.6 kV transformers
Y
Y
CB
Zone substation 22, 11 or 6.6 kV bus
CB
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.

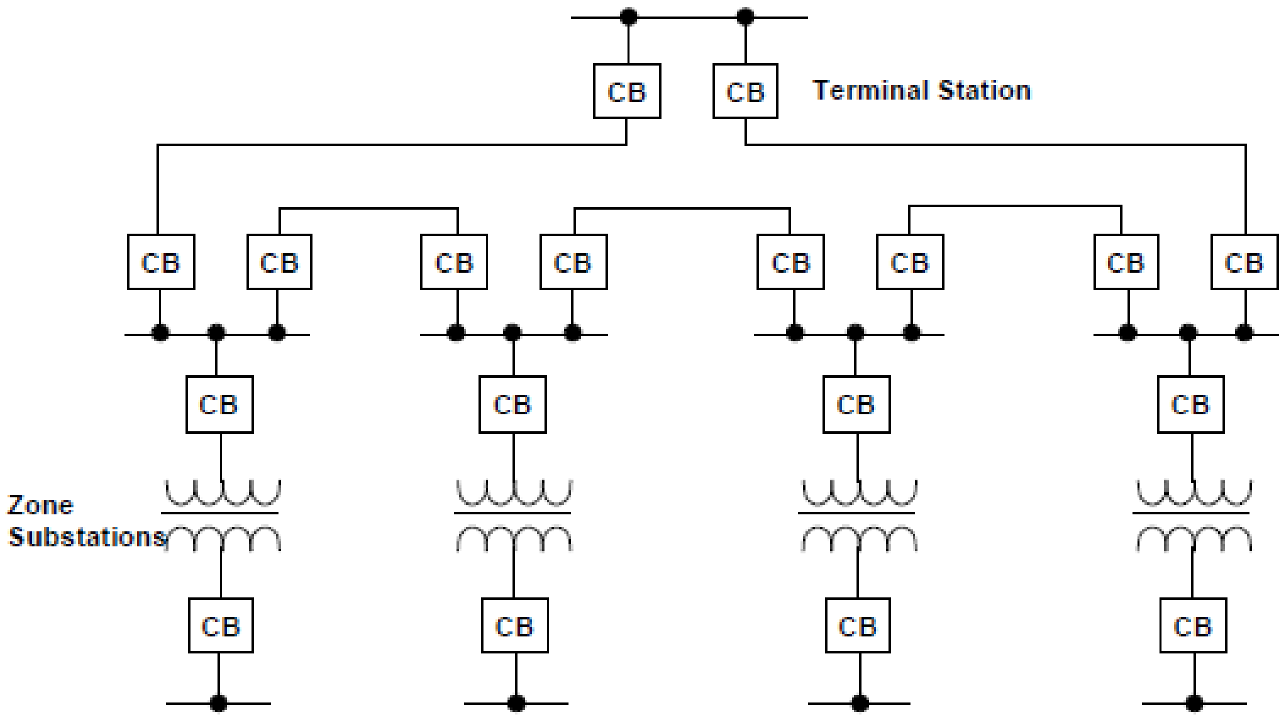
2.4 Ring main

- 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.

2.5 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

3. 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.

End of lecture!