**Name of the teacher— Mrs. Monika Sharma**

**Department of Physics and Electronics**

**Name of the course— B.Sc. (H) Physics**

**Semester- IV**

**Name of the paper—Electrical circuits and Network Skills**

**Paper code-32223903**

**Lecture timings: 10:40 to 12:40 AM**

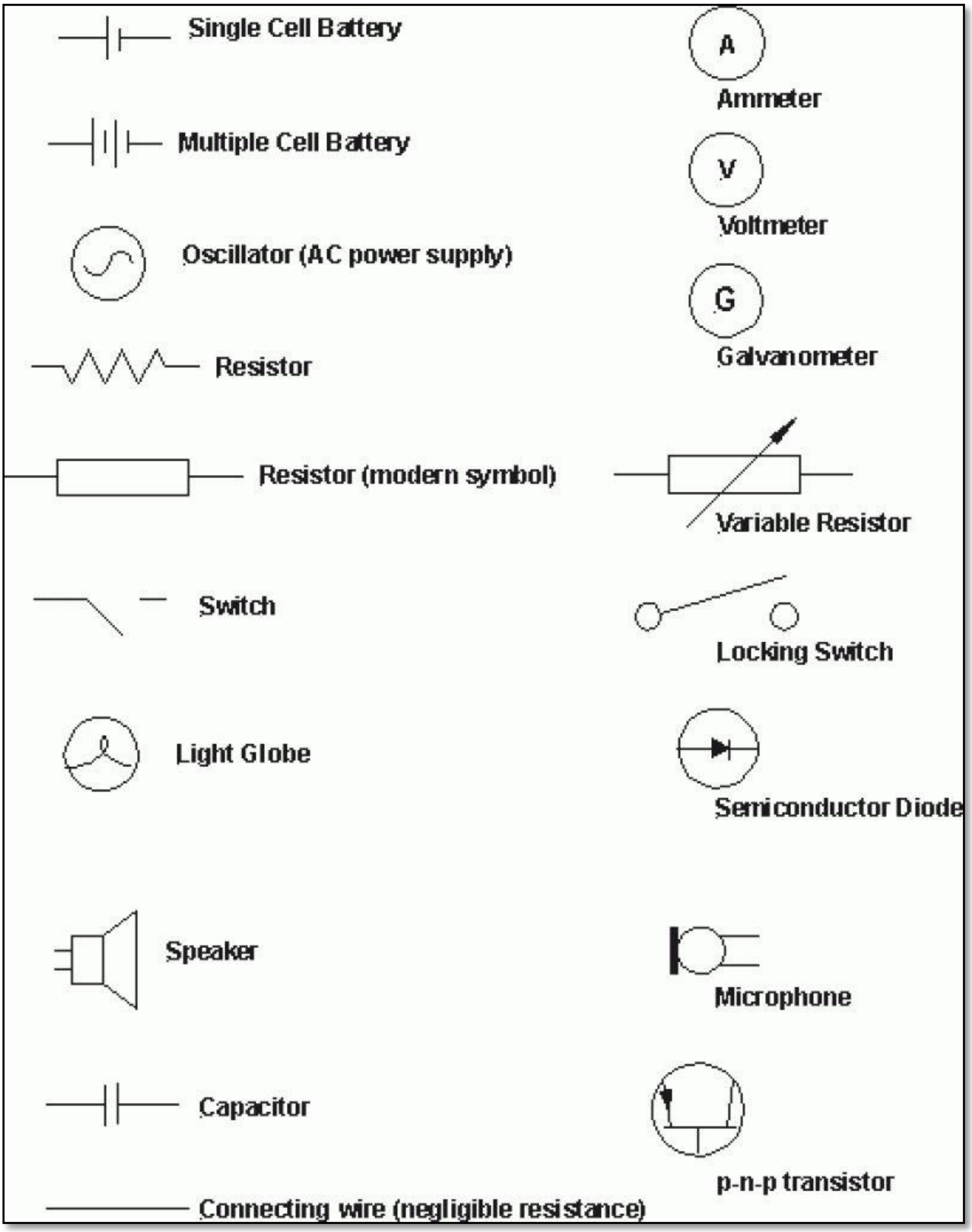
**Topics to be covered:**

**Name of the unit: Electrical drawing and symbols**

- *Drawing symbols for basic circuit elements*
- *Electrical schematic symbols*
- *Ladder diagrams*
- *Power circuits and control circuits*

## Drawing symbols for basic circuit elements

Below are the drawing symbols for the basic elements used in electrical circuits.

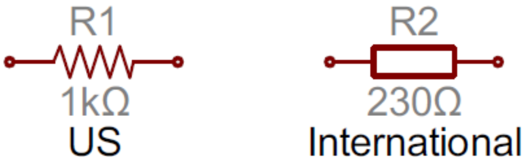


## Electrical Schematic Symbols

Here are some of the standardized, basic schematic symbols for various components.

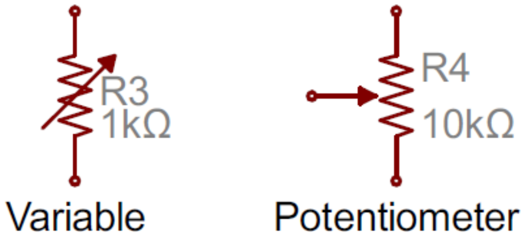
### Resistors

The most fundamental of circuit components and symbols! Resistors on a schematic are usually represented by a few zig-zag lines, with **two terminals** extending outward. Schematics using international symbols may instead use a featureless rectangle, instead of the squiggles.



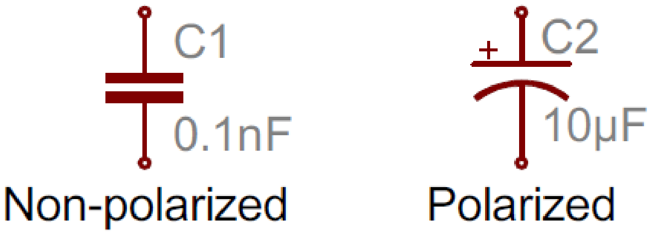

### Potentiometers and Variable Resistors

Variable resistors and potentiometers each augment the standard resistor symbol with an arrow. The variable resistor remains a two-terminal device, so the arrow is just laid diagonally across the middle. A potentiometer is a three-terminal device, so the arrow becomes the third terminal (the wiper).




### Capacitors

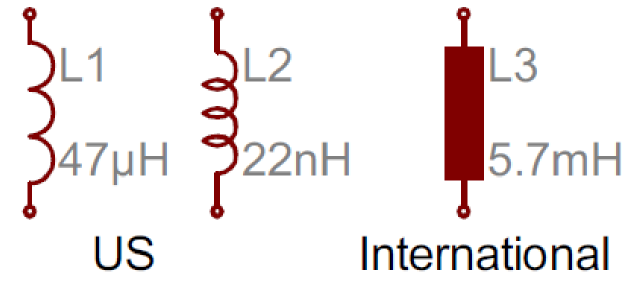
There are two commonly used capacitor symbols. One symbol represents a polarized (usually electrolytic or tantalum) capacitor, and the other is for non-polarized caps. In each case there are two terminals, running perpendicularly into plates.




The symbol with one curved plate indicates that the capacitor is polarized. The curved plate usually represents the cathode of the capacitor, which should be at a lower voltage than the positive, anode pin. A plus sign should also be added to the positive pin of the polarized capacitor symbol.

### Inductors

Inductors are usually represented by either a series of curved bumps, or loopy coils. International symbols may just define an inductor as a filled-in rectangle.

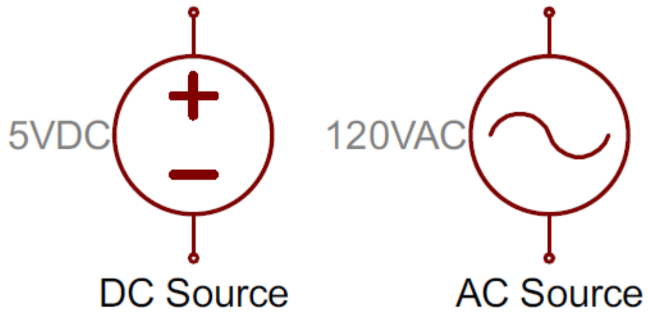



**Power Sources**

Just as there are many options out there for powering your project, there are a wide variety of power source circuit symbols to help specify the power source.

DC or AC Voltage Sources

Most of the time when working with electronics, you'll be using constant voltage sources. We can use either of these two symbols to define whether the source is supplying direct current (DC) or alternating current (AC):



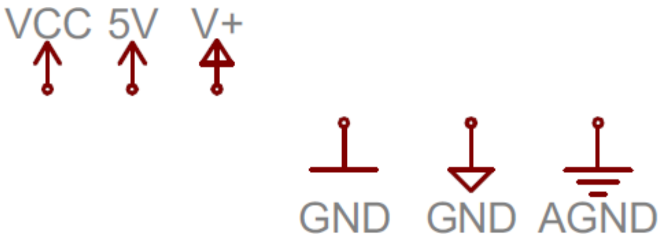

**Batteries**

Batteries, whether they're those cylindrical, alkaline AA's or rechargeable lithium-polymers, usually look like a pair of disproportionate, parallel lines:


More pairs of lines usually indicates more series cells in the battery. Also, the longer line is usually used to represent the positive terminal, while the shorter line connects to the negative terminal.

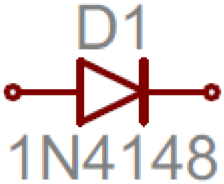
**Voltage Nodes**

Sometimes -- on really busy schematics especially -- you can assign special symbols to node voltages. You can connect devices to these **one-terminal** symbols, and it'll be tied directly to 5V, 3.3V, VCC, or GND (ground). Positive voltage nodes are usually indicated by an arrow pointing up, while ground nodes usually involve one to three flat lines (or sometimes a down-pointing arrow or triangle).

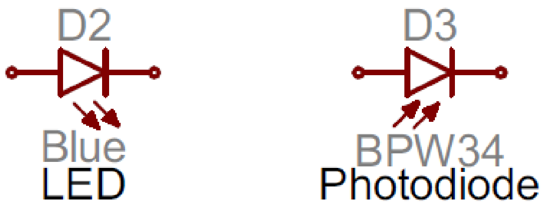



**Diodes**

Basic diodes are usually represented with a triangle pressed up against a line. Diodes are also polarized, so each of the two terminals require distinguishing identifiers. The positive, anode is the terminal running into the flat edge of the triangle. The negative, cathode extends out of the line in the symbol (think of it as a - sign).




There are a all sorts of different types of diodes, each of which has a special riff on the standard diode symbol. **Light-emitting diodes (LEDs)** augment the diode symbol with a couple lines pointing away. **Photodiodes**, which generate energy from light (basically, tiny solar cells), flip the arrows around and point them toward the diode.



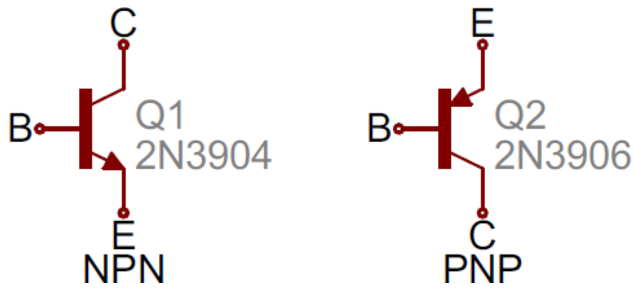

Other special types of diodes, like Schottky's or zeners, have their own symbols, with slight variations on the bar part of the symbol.


**Transistors**

Transistors, whether they're BJTs or MOSFETs, can exist in two configurations: positively doped, or negatively doped. So for each of these types of transistor, there are at least two ways to draw it.

**Bipolar Junction Transistors (BJTs)**

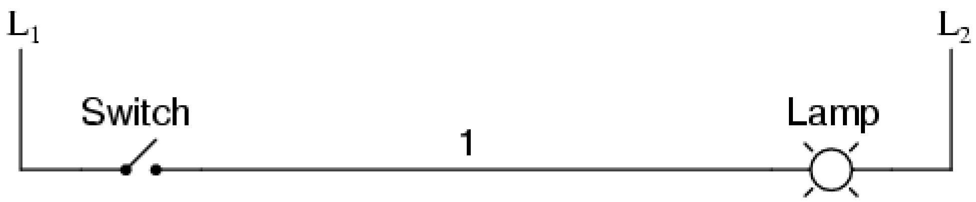
BJTs are three-terminal devices; they have a collector (C), emitter (E), and a base (B). There are two types of BJTs -- NPNs and PNPs -- and each has its own unique symbol.



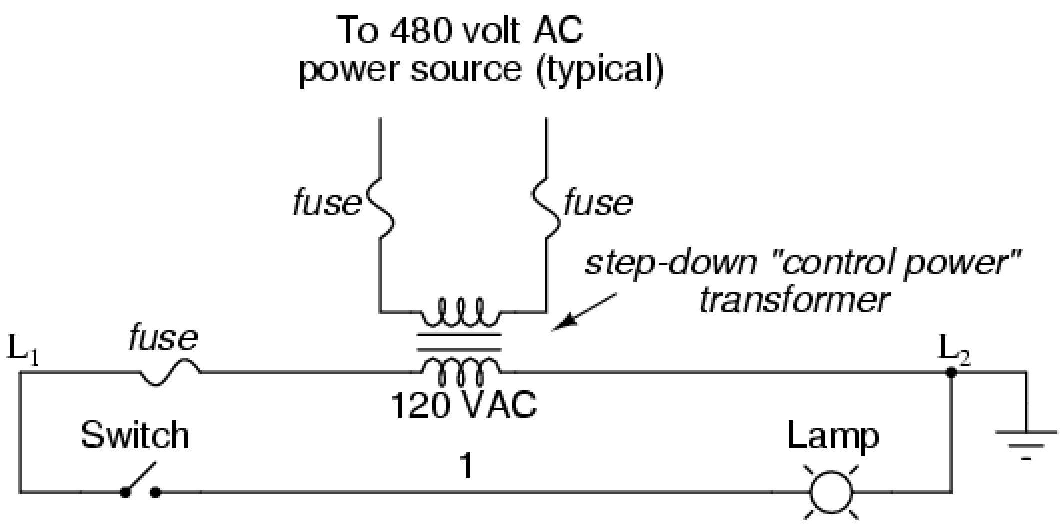

The collector (C) and emitter (E) pins are both in-line with each other, but the emitter should always have an arrow on it. If the arrow is pointing inward, it's a PNP, and, if the arrow is pointing outward, it's an NPN. A mnemonic for remembering which is which is "NPN: **n**ot **p**ointing i**n**."

## Ladder diagrams

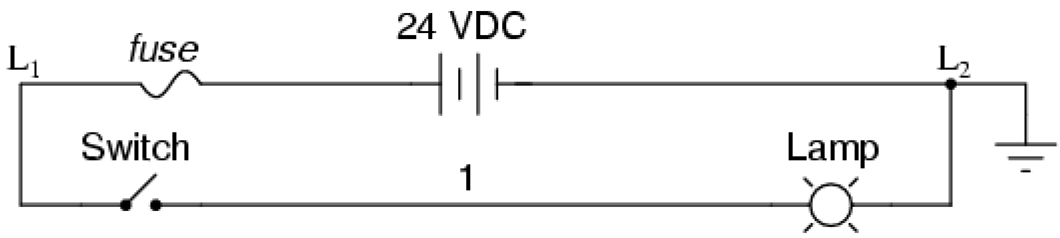
Ladder diagrams are specialized schematics commonly used to document industrial control logic systems. They are called "ladder" diagrams because they resemble a ladder, with two vertical rails (supply power) and as many "rungs" (horizontal lines) as there are control circuits to represent. If we wanted to draw a simple ladder diagram showing a lamp that is controlled by a hand switch, it would look like this:




The "$L_1$" and "$L_2$" designations refer to the two poles of a 120 VAC supply unless otherwise noted. $L_1$ is the "hot" conductor, and $L_2$ is the grounded ("neutral") conductor. These designations have nothing to do with inductors, just to make things confusing. The actual transformer or generator supplying power to this circuit is omitted for simplicity. In reality, the circuit looks something like this:



Typically in industrial relay logic circuits, but not always, the operating voltage for the switch contacts and relay coils will be 120 volts AC. Lower voltage AC and even DC systems are sometimes built and documented according to "ladder" diagrams:




So long as the switch contacts and relay coils are all adequately rated, it really doesn't matter what level of voltage is chosen for the system to operate with. Note the number "1" on the wire between the switch and the lamp. In the real world, that wire would be labeled with that number, using heat-shrink or adhesive tags, wherever it was convenient to identify. Wires leading to the switch would be labeled "$L_1$" and "1," respectively. Wires leading to the lamp would be labeled "1" and "$L_2$," respectively. These wire numbers make assembly and maintenance very easy. Each conductor has its own unique wire number for the control system that its used in. Wire numbers do not change at any junction or node, even if wire size, color, or length changes going into or out of a connection point. Of course, it is preferable to maintain consistent wire colors, but this is not always practical. What matters is that any one, electrically continuous point in a control circuit possesses the same wire number.

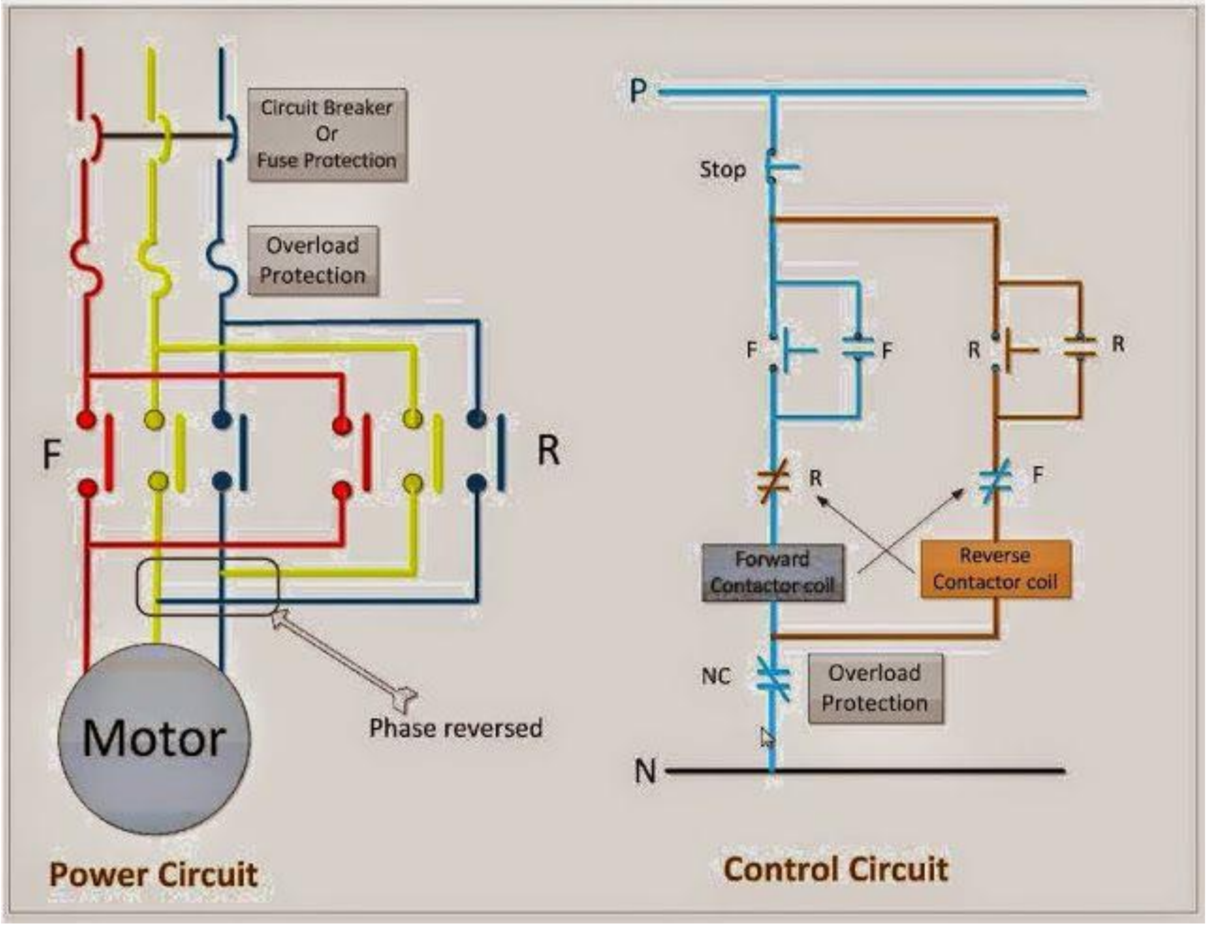
## Power circuits and control circuits

A power circuit provides significant electrical capacity to operate something that does a lot of work, for example high power heaters or multi-horsepower motors. There is a load or loads that consume X watts of power to perform a function. In the context of the question, this usually implies 240VAC ~ 600VAC 3 phase. These types of circuits can draw in the kilowatts of power.

A control circuit is a lower, single phase power line that could also be as low as 24V that provides a much lower level of power to operate control logic, contactors, displays, relays, and communications. A control circuit also draws on the AC power line but is usually just a few hundred watts at most. The important difference is that the devices in the control circuit are operating at 120 volts single phase or lower. It also should be pointed out that control power is usually derived from the resident power circuit by means of a step-down transformer.

The reason for control circuits are that displays, indicators, and panel controls and switches are not designed to operate on 240 to 600AC 3 phase. If a panel switch failed and arced with a potential of 440V present, trust me you would NOT want to be anywhere near that switch!

The control circuit uses contactors or high power solid state devices to control stuff on the power circuit side. This buffer between the two types of circuits provides a margin of safety as well as limits the size of the controls needed on the panel. Can you imagine the size of switch needed if you controlled a 600 ton press motor directly? The switch would probably be the the size of toaster. So, a smaller switch will control a motor contactor, which is hidden inside of a housing and safely shielding the user if it should fail catastrophically.


Circuit Breaker
Or
Fuse Protection
Overload
Protection
F
R
Motor
Phase reversed
Power Circuit
P
Stop
F
F
R
R
R
F
Forward
Contactor coil
Reverse
Contactor coil
NC
Overload
Protection
N
Control Circuit