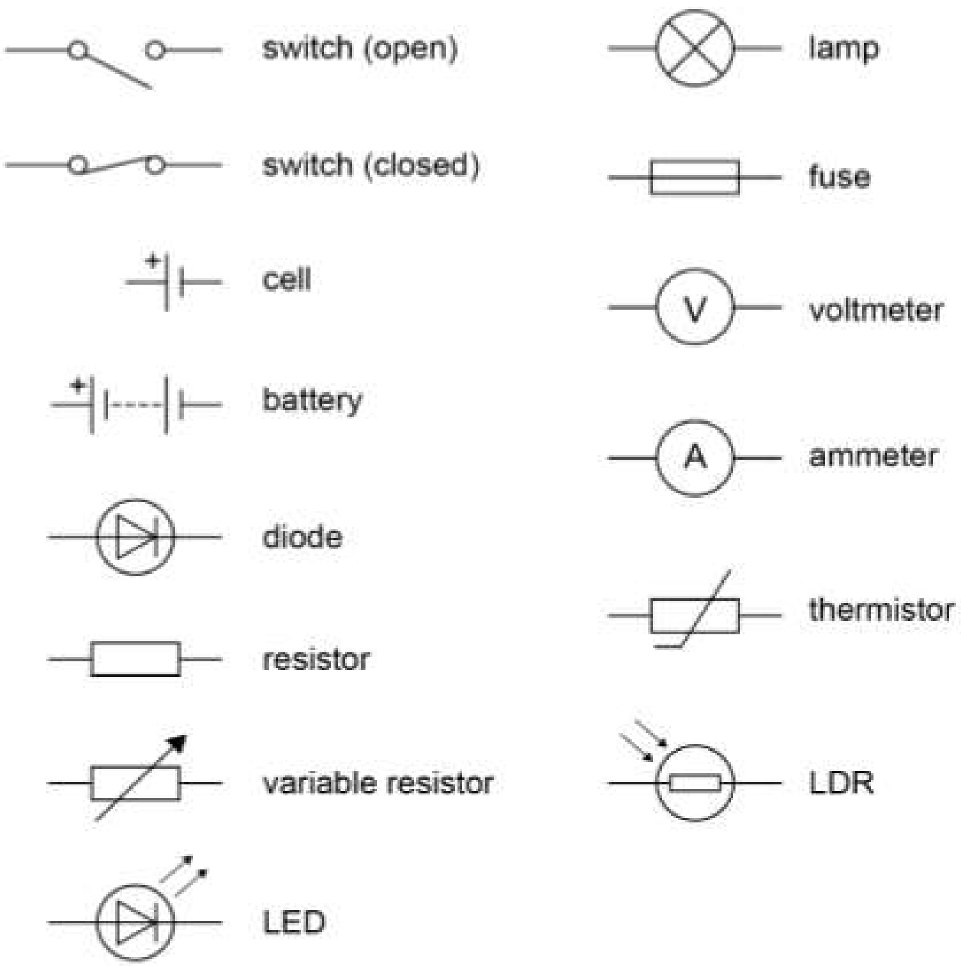
Physics Knowledge Organiser
Electricity (Triple Science)

Circuit Symbols



Electric charge and current

Current is the flow of electrical **charges (electrons)**

The size of electric current is the rate of flow of electrical charge.

Charge Flow Equation

You will need to learn this equation.

$Q = I \times t$

Q = Charge in coulombs (C)
I = Current in amps (A)
t = time in seconds (s)

Current, resistance and potential difference

Resistance is how easily electrical charge can flow in a circuit or component.

Potential difference is the energy given to charge so it can move through the circuit.

The greater the resistance of a component, the smaller the current for a given potential difference across the component.

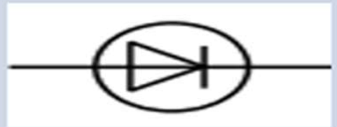
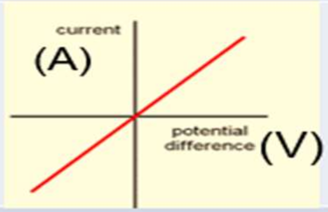
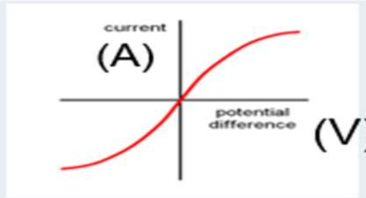
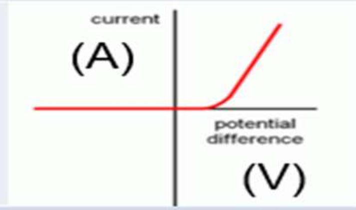
Ohms Law Equation

You will need to learn this equation.

$V = I \times R$

V = Potential difference (or Voltage) in volts (V)
I = Current in amps (A)
R = Resistance in ohms (Ω)

IV (current potential difference) graphs and explanations of graphs

Circuit Component	Resistor	Filament Lamp	Diode
Circuit Symbol			
IV Graph			
Resistance	Constant	Resistance changes	Very high as first then decreases.
Obeys Ohms Law (V = I x R)	Yes	No	No
Explanation for graph shape	As the **potential difference increases**, the **current increases** through the device.	As the **potential difference increases**, the **current increases**, **temperature** of the filament lamp **increases**. This causes an **increase** in **resistance**.	The diode has a **very high resistance** in **one direction**.

Resistance of a wire Practical

Setup and graph of results

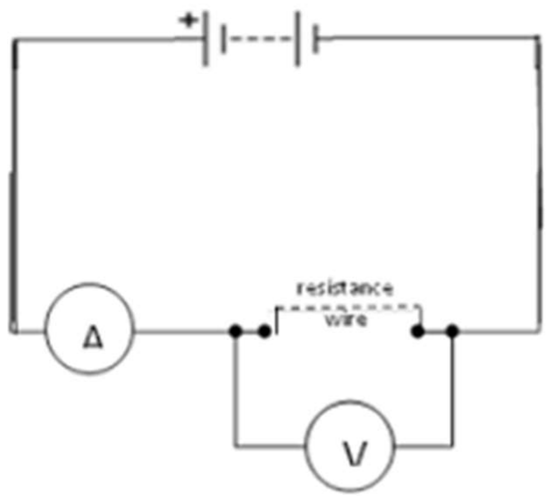


Figure 1: Practical setup

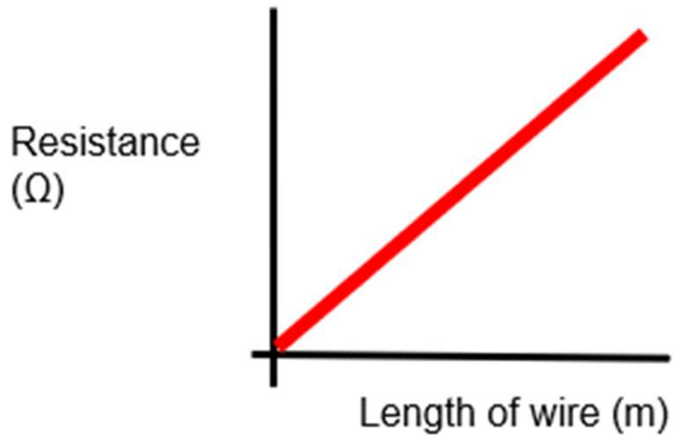


Figure 2: Experimental results length of wire vs resistance graph.

Experimental method

1) Set up the circuit in figure 1 with the ammeter in series and the voltmeter in parallel to the wire being tested.
2) After setting up the circuit, measure a length of wire of 10cm between the crocodile clips.
3) Turn on the power supply and record the current and potential difference.
4) Turn off the power supply and repeat step 2 and 3 for 5 different lengths of wire varied by 10cm each time.
5) Repeat the values for each length 3 times and calculate the mean for each value.
6) Calculate the resistance at each length by using V = I x R and rearrange for R.
7) Plot a graph of length of wire vs resistance. The relationship should be directly proportional as shown on the graph.

IV Characteristics Practical

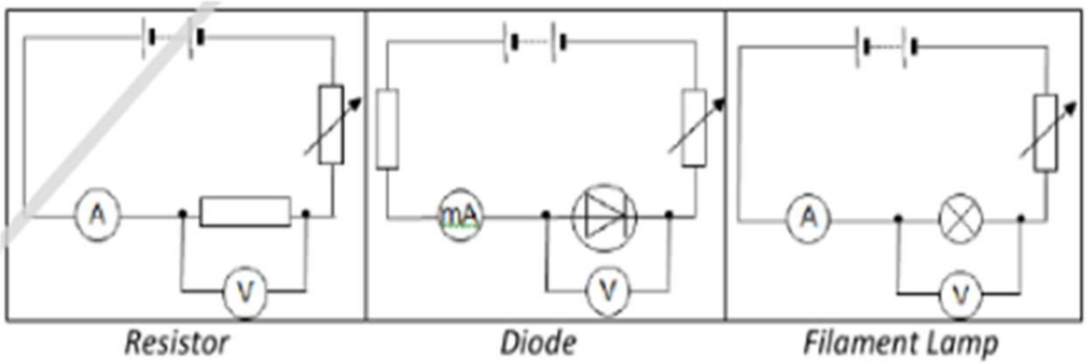


Figure 1: Practical setup with all three components.

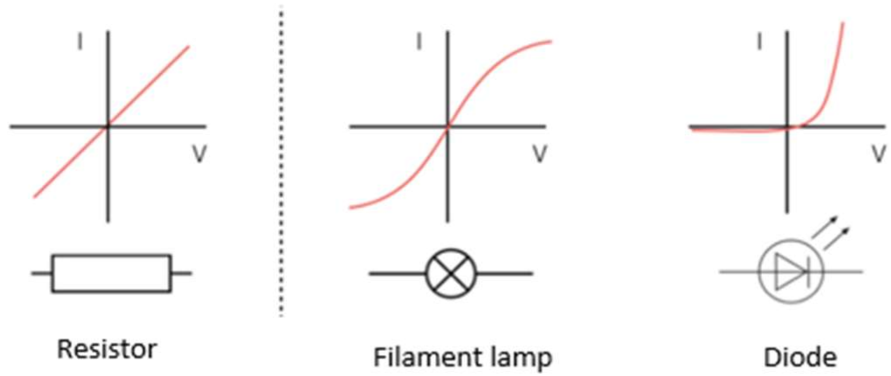


Figure 2: Experimental results Current, I vs potential difference, V graphs for a resistor, filament lamp and diode.

Experimental method

1) Set up the circuit with a resistor with the ammeter in series and voltmeter in parallel to the resistor and set the power supply at 6V.

2) Turn on the power supply and record the current and potential difference. Repeat twice and calculate a mean.

3) Turn off the power supply and move the variable resistor a set distance to change the resistance and repeat step 2.

4) Repeat step 2 to 3 for with a filament lamp and a diode and plot all three graphs on a current, I vs potential difference, V graph and draw a line of best fit for each graph. The graphs obtained should be the same as those in figure 2.

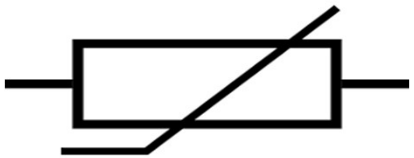
LDRs and Thermistors

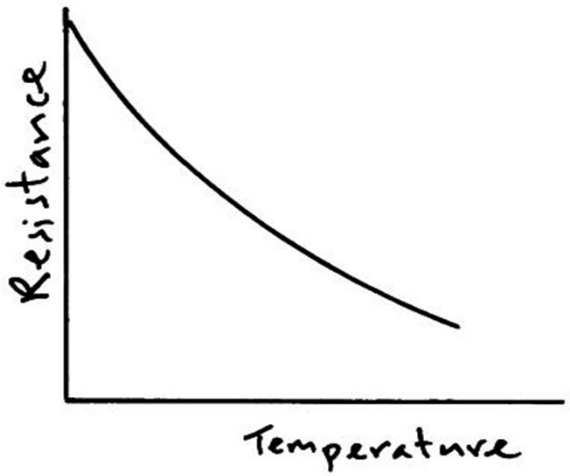
Thermistors and LDRs are resistors affected by temperature and light intensity.
A thermistor is where the resistance varies with temperature.
A light dependant resistor (L.D.R) is where the resistance varies with light intensity.

LDRs and Thermistors Graphs and explanations

Thermistor

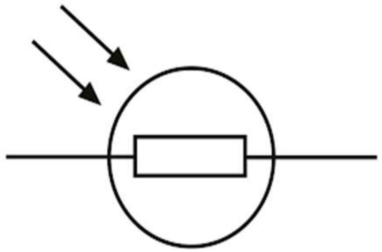
As the temperature increases, the resistance decreases

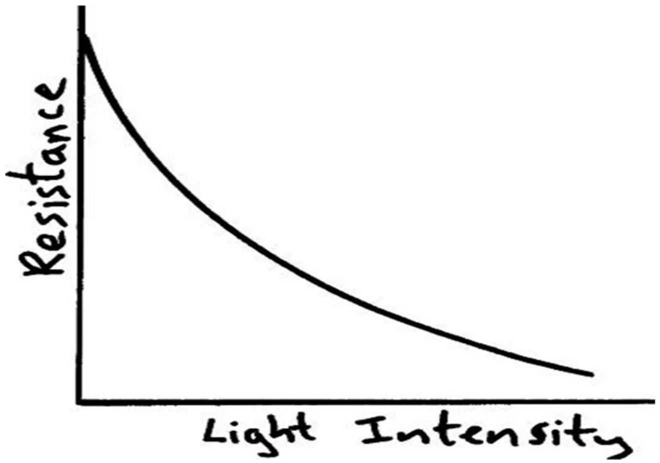




LDR

As the light intensity increases, the resistance decreases





Applications of LDRs and Thermistors

LDRs

Outside Lighting
Street Lighting
Adaptive Phone Displays

Thermistors

Central heating
Climate control in cars
Ovens and kitchen hobs

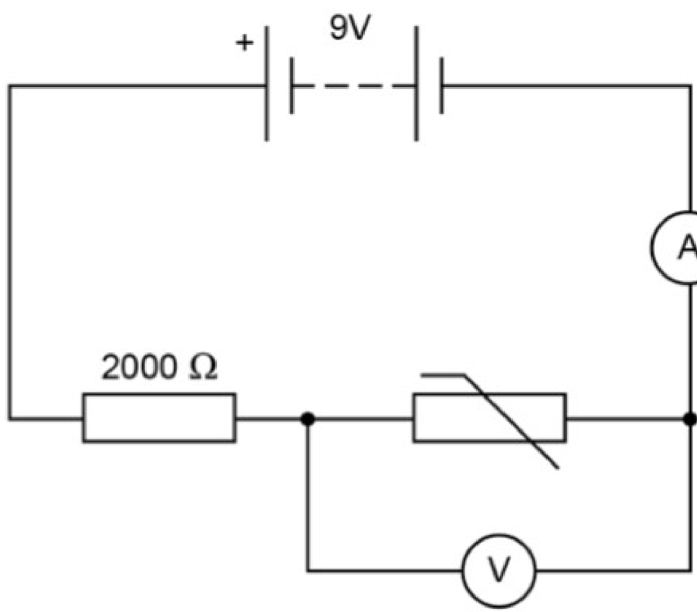
Series Circuits

All components are connected on a single loop, branch or path.

Circuits rules

Current	**The current is the same at all points in the circuit.**
Potential difference	The potential difference is shared between all components in the circuit.
Resistance	The total resistance is the sum of all individual resistances.

Series Circuit example



a) The total resistance

$R_t = R_1 + R_2$

$R_t = 20 + 70 = 90\Omega$

b) The current in the circuit

$V = I \times R$

$$I = \frac{9}{90} = 0.1A$$

C) The potential difference across each resistor. $V = I \times R$

$R_1 = 20\Omega$	$I = 0.1A$	$V_1 = 0.1 \times 20$	$= 2V$
$R_2 = 70\Omega$	$I = 0.1A$	$V_2 = 0.1 \times 70$	$= 7V$

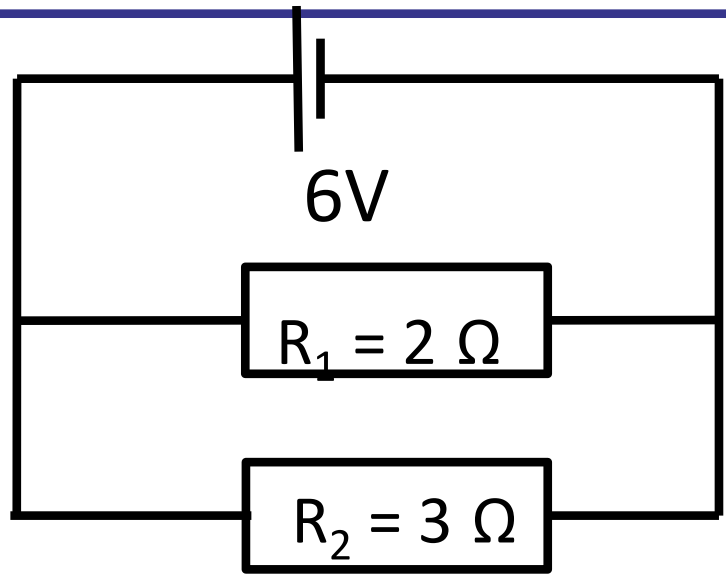
Parallel Circuits

Components are connected together in two or more loops, branches or paths.

Circuits rules

Current	The current is split between all paths.
Potential difference	The potential difference is the same across each loop.
Resistance	The total resistance is less than the path with the lowest resistance.

Parallel Circuit example



a) State the potential difference across each resistor.
b) Calculate the current through each resistor.
c) Calculate the current through the cell.

a) Potential difference is the same across each branch.
Therefore potential difference across each resistor is 6V.

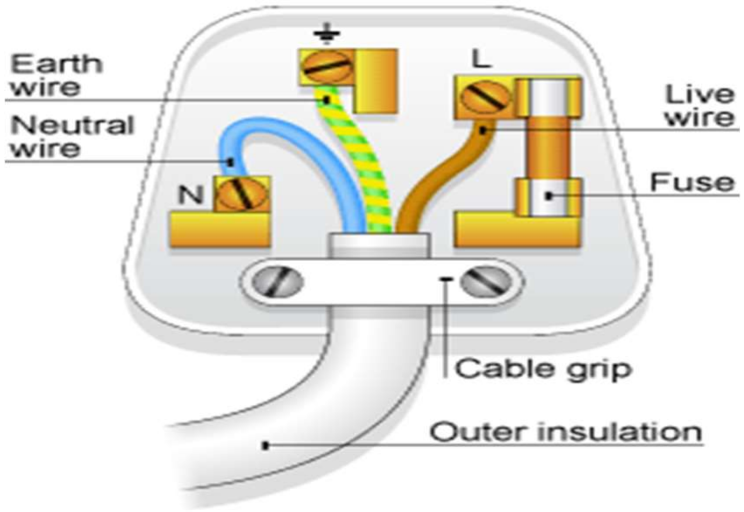
b) $R_1 = 2\Omega$ $V_1 = 6V$ $I=V/R$ $= 3A$
$R_2 = 3\Omega$ $V_2 = 6V$ $I=V/R$ $= 2A$

c) Current is the sum of the currents
Current through the cell = 3A + 2A = 5A

Plugs

Component	Function
Live Wire	It carries the current to the appliance at a potential difference of 230V.
Neutral wire	It completes the circuit, after the charge has flowed to the appliance. It has a potential difference of 0V.
Earth wire	This safety feature connected the metal case to earth, preventing the case becoming live.
Fuse	This melts if too much current flows.
Outer insulation	This prevents the user getting an electric shock

Diagram of a 3 pin plug

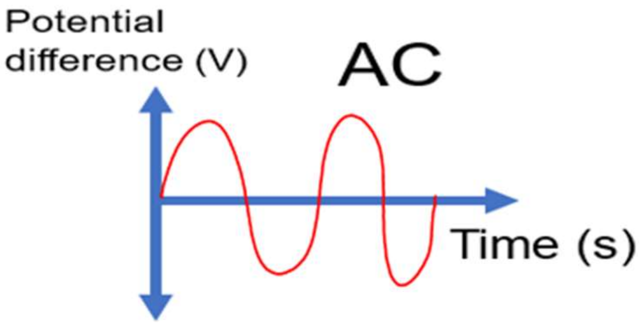


Main Electricity

In the UK, the potential difference of a mains electricity supply is 230V and its frequency is 50Hz.

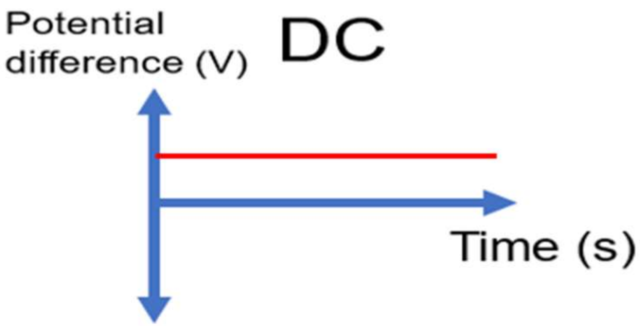
- Mains electricity uses alternating current.
- Batteries, cells and solar cells uses direct current.

Alternating current



- Potential difference continuously changes direction
- Potential difference varies in size.

Direct current



Potential difference is in one direction and stays the same size.

Power Equations

Power is the rate at which energy is transferred between devices.
(It is the energy transferred every second).

You will need to learn the following two equations

Equation 1: P = V x I
Equation 2: $P = I^2 \times R$
P = Power in Watts (W)
V = Potential difference (or Voltage) in volts (V)
I = Current in amps (A)
R = Resistance in ohms (Ω)

Example 1: Applying the $P = I \times V$ equation.

Calculate the power transfer to a Samsung Galaxy Note20 Ultra for a mains potential difference of 230V with a current of 0.1A.

$P = I \times V$
P = 230 x 0.1
P = 23W

Examples of using $P = I^2 \times R$ equations:

Example 1: Applying the $P = I^2 \times R$ equation.

Calculate the max power transferred by a Tesla Model S wall connector when it has a current of 48A with a resistance of 5Ω

$P = I^2 \times R$
I = 48A R = 5Ω
P = $(48)^2 \times 5$
P = 11,520W

Example 2: Rearranging the $P = I^2 \times R$ equation for current, I

Calculate the current used in an electric heater if the power dissipated is 500W and the resistance was 20Ω.
P = I^2 x R
500 = I^2 x 20
$\frac{500}{20} = I^2$
$\sqrt{\frac{500}{20}}$ = I
I = 5A

Energy Equations

You will need to learn the following two equations

Equation 1: $E = P \times t$

Equation 2: $E = Q \times V$

E = Energy transferred in joules (J)
P = Power in Watts (W)
t = time in seconds (s)
Q = Charge in coulombs (C)
V = Potential difference (or Voltage) in volts (V)

Example 1: Applying the $E = P \times t$ equation.
Calculate the energy transferred by a 3000W toaster in 20 seconds.

$E = P \times t$

$E = 3000 \times 20$

$E = 60{,}000J$

Examples of using the P = V x I equations:

Example 1: Applying the $E = Q \times V$ equation.

Calculate the energy transferred when 5C of charge to flow through an electric toothbrush across a potential difference of 230V.

E = Q X V
E = 5 X 230
E = 1150J

Example 2: Rearranging the $E = Q \times V$ equation

5000J of energy is transferred to a speaker system when 20C of charge passed through it. Calculate the potential difference in the circuit.

E = Q x V

5000 = 20 x V

$\frac{5000}{20} = V$

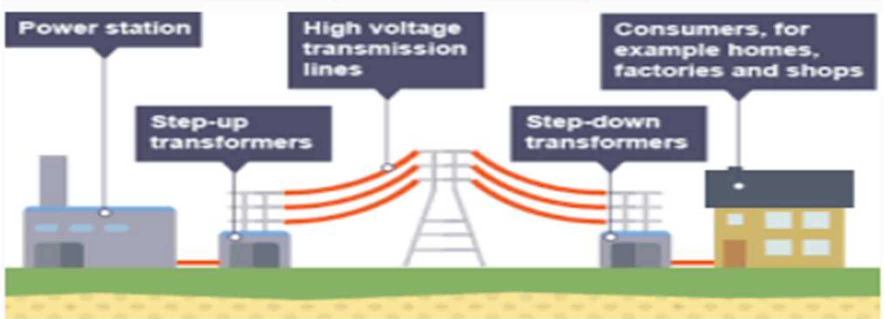
V = 250V

The National Grid

The national grid consists of 2 mains parts:

1) The transformers (step up and step down)
2) The Transmission cables.

Electrical power is transferred from power stations to consumers using the national grid.



Step up transformers

- The potential difference increases
- The current decreases
- Improves efficiency by reducing energy wasted as heat in the wires.

Step down transformers

- The potential difference decreases. This make it safe for domestic use.
- The current increases

Transmission Cables

These have a low resistance to reducing energy wasted as heat in the wires.