MAGNETS OVERVIEW

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Introduction

Purpose

- Explore the magnet technology and how they are used in the electronics industry

Objectives

- Define key terms of magnets
- Describe what magnets are and what they can do
- Describe what and how they are used

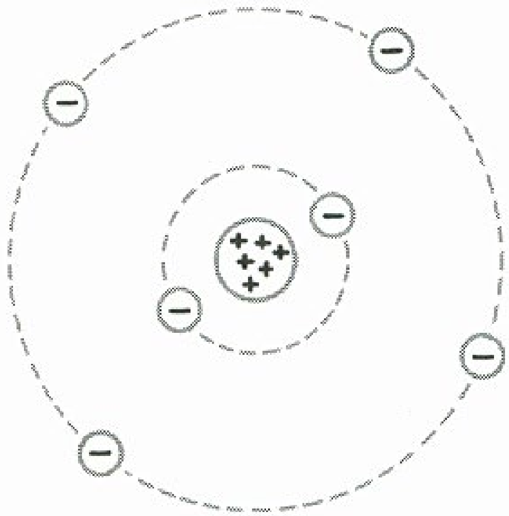
Introduction

Let's pose a few questions

- What is magnetic? Where does it come from?
- What is a magnet?
- What is a dipole?
- Where does the energy come from?
- What are a magnet's properties - and why do we care?
- What affects magnets? How does one make an artificial magnet?
- How does one make a magnetic field?
- What is the Curie effect?
- Are there different types of magnets?

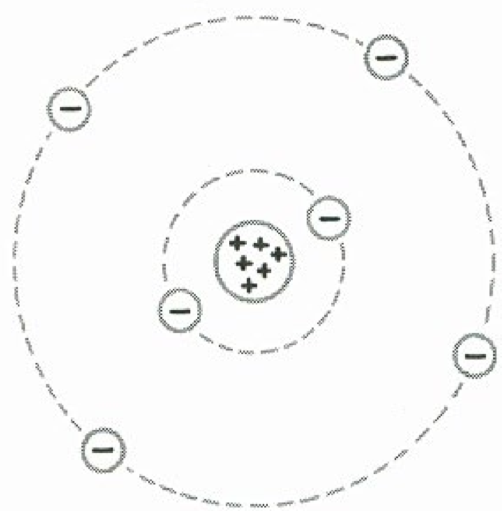
What is magnetic?

- The magnetic effect is created at the sub-atomic level
- An atom has a nucleus composed of protons and neutrons. Electrons encircle the nucleus
- Two things occur in an atom that produce a magnetic field
- Both by the negatively charged electrons



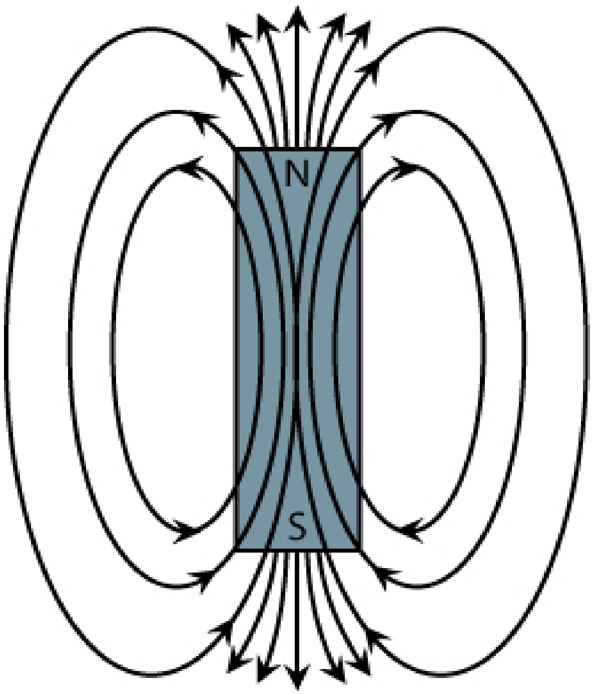
What is magnetic?

- Electrons by their very nature spin
- Also electrons circulate around the nucleus of the atom
- As electrons circulate around the nucleus they generate an angular momentum
- Net effect of spin and the angular momentum produces what is called a dipole



What is magnetic?

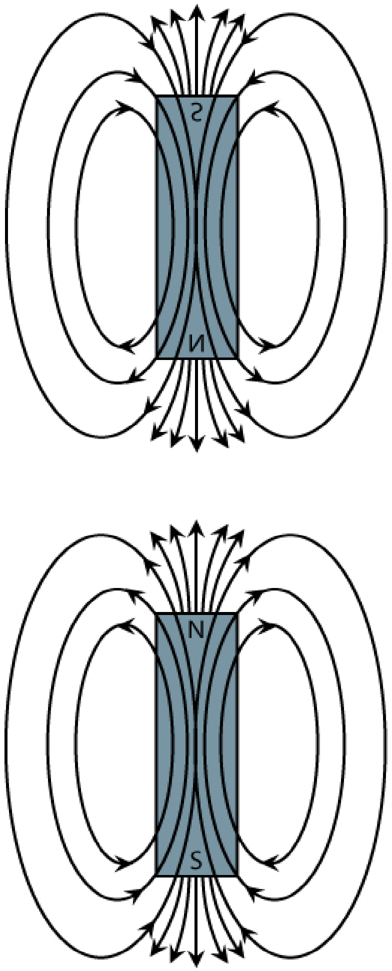
- The electron's spin and angular momentum produces a tiny magnet within the atom and it is called a dipole
- The dipole's magnetic field is very small



Dipole

What is magnetic?

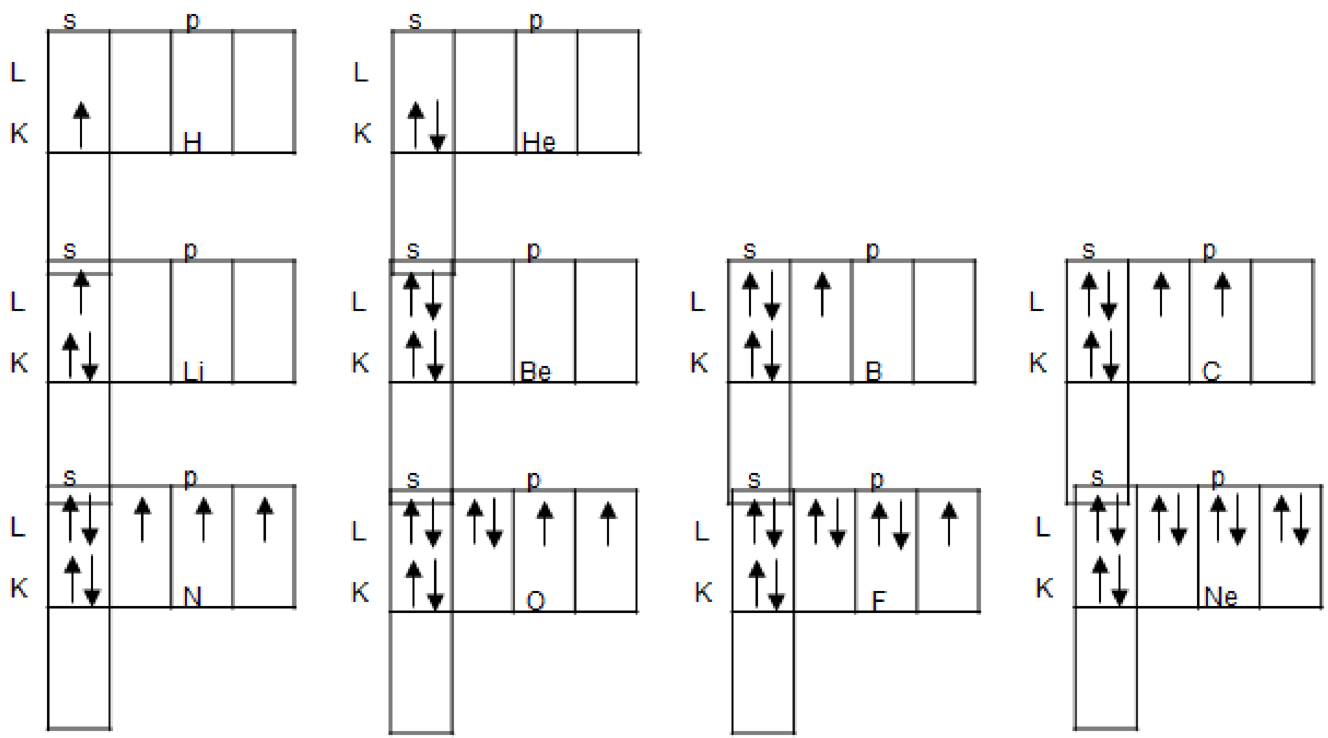
- Most atoms have more than one electron
- Two electrons in a atom will form a pair or two dipoles
- The two dipoles are equal and opposite in magnetic strength
- The magnetic fields of two electron pairs cancel each other out



Dipoles are equal and opposite

What is magnetic?

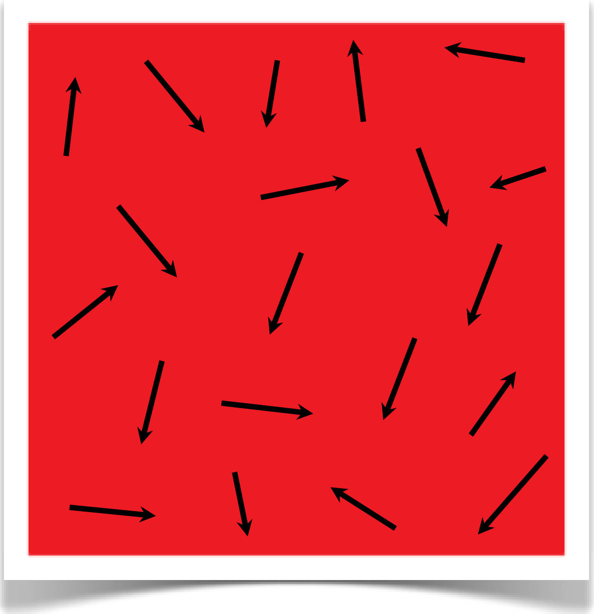
- With each additional pair of electrons within the atoms there will be an accompanying pair of dipoles
- Elements dipoles align themselves with an equal and opposite dipoles, canceling out overall magnetic effect.



What is magnetic?

- In several atoms the net magnetic effect does not cancel
- This is the case with many metals
- When the atoms are grouped together many billions of times over there is still no net magnetic field in the bulk material.
- This is because in most metals the dipoles remain locked in place

The arrows represent random singular dipoles



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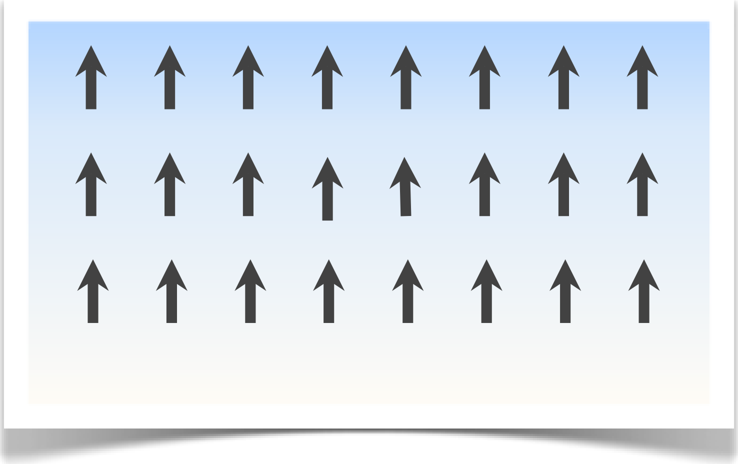
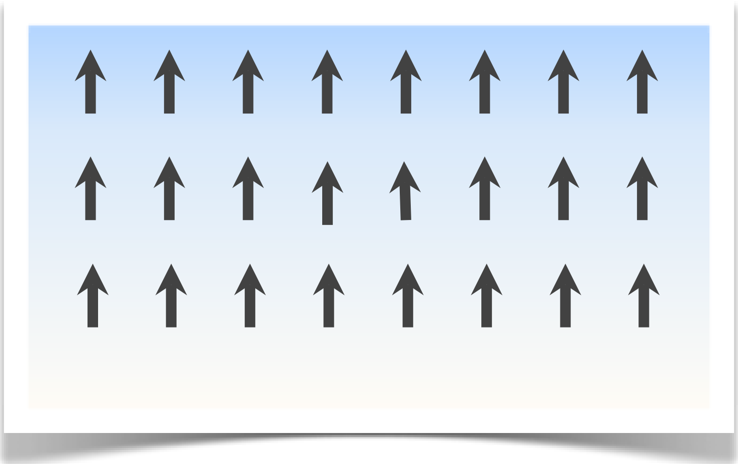
What is magnetic?

- Iron, nickel and cobalt are ferromagnetic elements that can occur naturally magnetized in nature
- This effect is shown to the right where the dipoles are all aligned
- These are called permanent magnets
- Most of the magnets we use in electronics are made into magnets by magnetic technology



What is magnetic?

- There are a few elements, where the dipoles are free to move when subject to a magnetic field
- The dipoles will align themselves and can become 'locked in place' in the crystal's lattice structure
- There are other ferromagnetic materials where the dipoles align when subject to a magnetic field
- However, when the magnetic field is removed the dipoles revert to their random structure



Magnetic Properties

ALL MAGNETS HAVE DIFFERENT PROPERTIES

THE PROPERTIES OF EACH ALLOW US TO SELECTIVELY USE THEM IN DIFFERENT APPLICATIONS

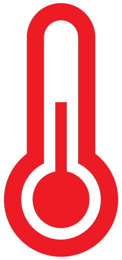
Magnetic Properties – Used in a Relay or Sensor

- Magnetize and demagnetize easily
- Temperature stability
- Magnetic strength
- Magnet size

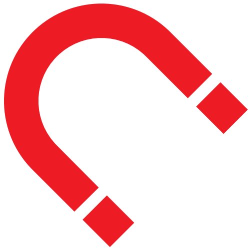
Magnetic Properties

- Curie Temperature
- Stability
- Shock
- Cost and availability

Temperature Effects



At temperatures >150°C use high temperature stability magnets such as AlNiCo series and rare earth samarium cobalt (SmCo)



Most magnets are relatively stable at temperatures 0°C and below

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Temperature Effects

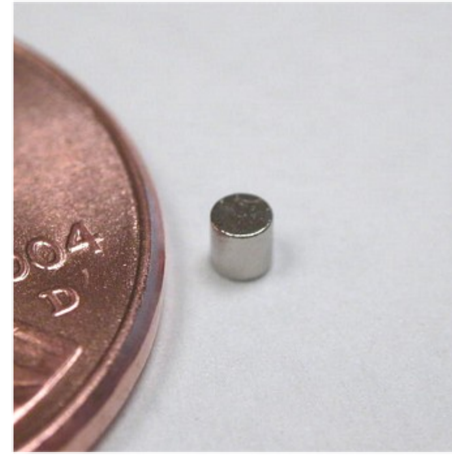
Magnet Type	Low Temperature	High Temperature	Comments
SmCo Magnets	Stable to 4ºK	Stable to 250ºC	Below 20ºC magnetic strength will rise slightly
NdFeB	Stable to 15ºK	Stable to 160ºC	Below 20ºC magnetic strength will rise slightly
Alnico magnets	Stable to near 0ºK	Stable up to 550ºC	Most stable of all magnetic materials
Ferrite magnets	Stable to -10ºC	Stable to 250ºC	At -20ºC they suffer a permanent loss of magnetism

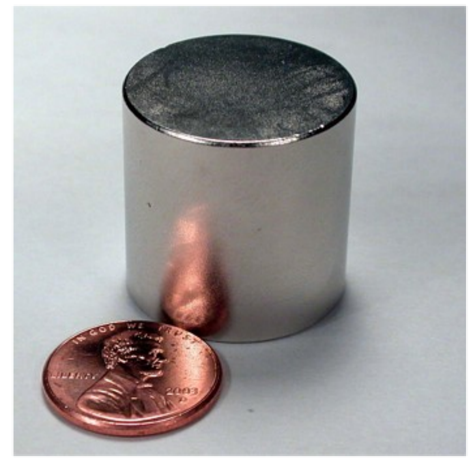
Magnetic Strength

- Magnetic strength determines distance where reed sensor will close and open
- The effects of other magnetic fields or ferromagnetic materials from nearby components may affect other magnetic components

Magnet Size

- Size also determines the operate points of sensor
- The greatest sensing distance is achieved when matching size and strength of the magnet





Images courtesy of amazingmagnets.com

Curie Temperature

- The Curie temperature of a magnet or ferromagnetic material is that temperature where the magnetic properties are lost
- The temperatures are usually quite high; however, they can and are reached in several applications

Curie Temperature

- Listing of different magnet types and their associated Curie temperatures

Material	Curie Temp. (K)	Curie Temp. (° C)	Curie Temp. (° F)
Co	1388	1115	2039
Fe	1043	770	1418
$FeOFe_2O_3$	858	858	1085
$NiOFe_2O_3$	858	585	1085
$CuOFe_2O_3$	728	455	851
$MgOFe_2O_3$	713	440	824
MnBi	630	357	674
Ni	627	354	669
MnSb	587	314	597
$MnOFe_2O_3$	573	300	571
$Y_3Fe_5O_{12}$	560	287	548
CrO_2	386	113	235
MnAs	318	45	113
Gd	292	19	18
Dy	88	-185	-301
EuO	69	-204	-335

Magnetic Stability

- Depending upon the application, stability can be an important parameter affecting the sensing distances for a given sensor
- Careful evaluation of the magnet specification needs to be considered

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Shock

01

Strong shock can change the magnetic strength for a given magnet.

02

If an application calls for an environment involving shock, care must be taken in selecting the correct magnet.

03

Shock can become a factor in a Form B or latching relay where relay handling at the customer site can cause enough shock to alter the operate points.

Types of Magnets

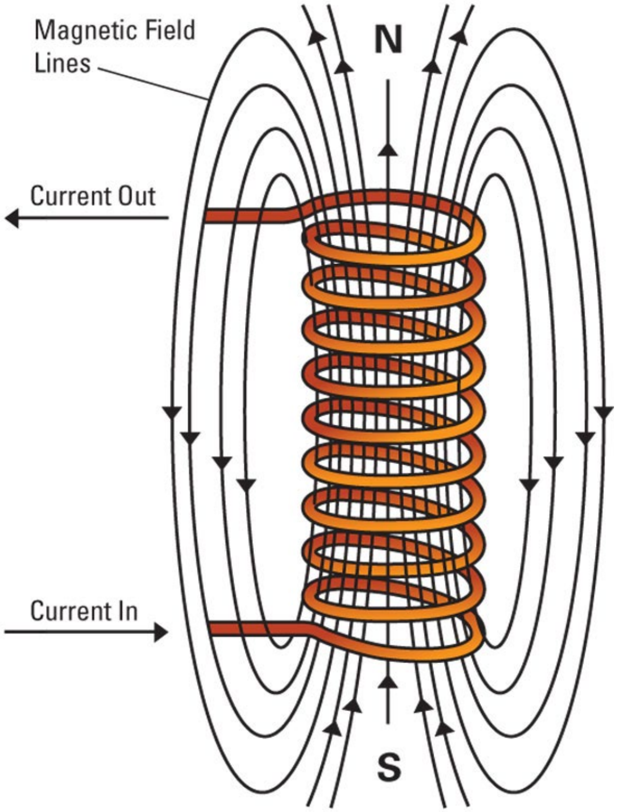
- Most common - Iron (Fe), nickel (Ni), and cobalt (Co)
- Less common - Chromium (Cr) and manganese (Mn)
- Very strong fields - Rare earth
- Most popular - Neodymium (NdFeB) and Samarium (SmCo)
- Magnets with combined elements (ex. AlNiCo)

Strong Magnetic Fields

- Much speculation about large magnetic fields physically distorting reed switches
- Once the reed blades are magnetically saturated, there is no increased field strength

Using Magnets

- A magnetic field can be generated by passing a current through a wire
- The simplest way to make a uniform magnetic field is with a solenoid or coil



MAGNETS

HOW THEY ARE USED IN THE ELECTRONICS INDUSTRY

How Magnets Are Used

Magnets are used in Reed Sensors

Magnets are used in some Reed Relays

Magnets

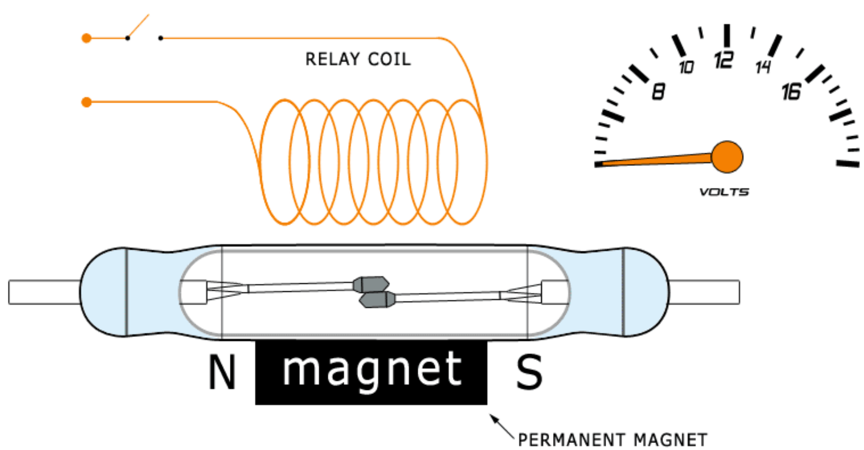
Used in Reed Relays

Reed Relays

- For normally closed or latching reed relays a magnet within the relay is required.
- Ability to magnetize and demagnetize the magnet for precise activate and deactivate points
- Stable results require the magnet fully magnetized then demagnetized to the best operating point

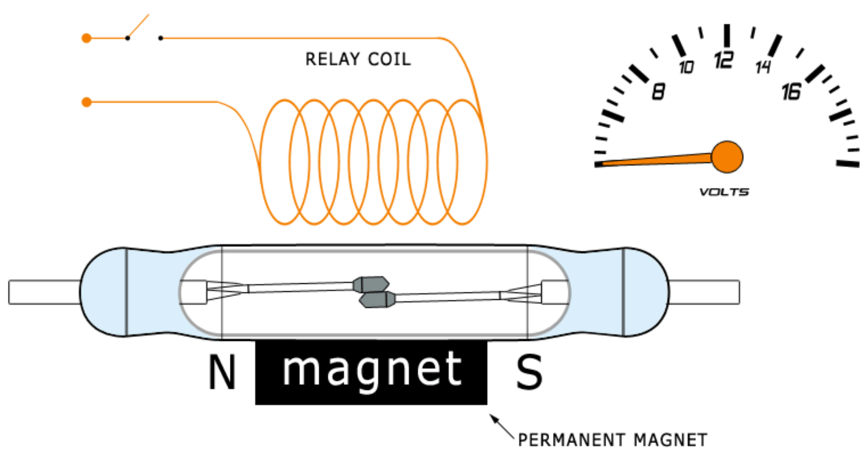
Reed Relays

- Magnet is placed inside the coil
- Magnet centered on reed switch gap and in parallel with the switch
- The two reeds within the reed switch become magnetized, with opposite polarity
- Opposite polarity causes the reeds to close



Reed Relays

- Power is applied to the reed relay coil, the magnetic field produced is equal and opposite in polarity
- The magnetic field produced by the coil opens the contacts
- Removing the coil power the contacts reclose
- This completes the cycle of how a normally closed reed relay works
- Latching relays occurs in a similar way



Reed Relays

- The best magnet types to use for reed relays
  - The AlNiCo series are usually best
  - Sintered magnets are also very good

MAGNETS

USED IN REED SENSORS

Reed Sensors

- Reed sensors require a magnet
- Reed sensors use the most magnets of any sensing technology
- Reed sensors use all types of magnets

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Reed Sensors

3 ways to use magnets		
Normally open sensor 1 magnet	Normally closed sensor 2 magnets	Latching sensors 2-3 magnets

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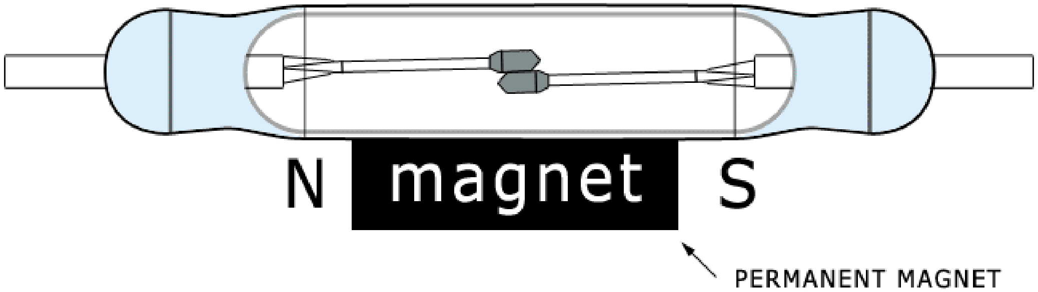
Reed Sensors – N.O. (Normally Open)

- Normally open reed sensors most popular
- Reed switch in a protective package and mounted on a PCB or directly wired
- Magnet is mounted to a moving element where its distance is being sensed
- Magnet entering reed switch's sphere of magnetic influence will close contacts

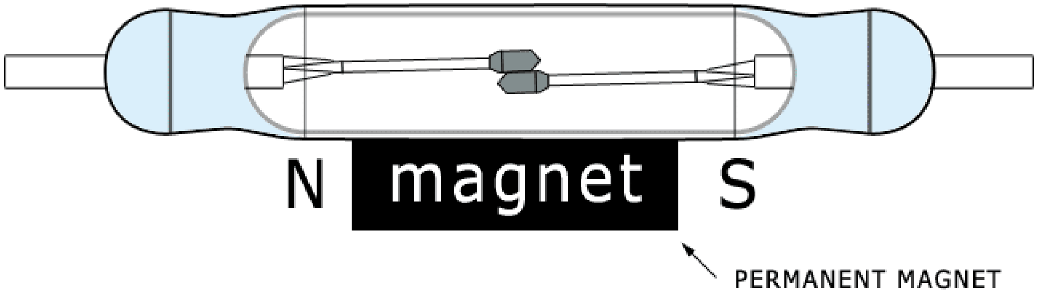
Reed Sensors – N.C. (Normally Closed)

- Normally closed reed sensors used in applications where contacts will be closed for long periods of time
- No power used when the contacts are closed
- Two magnets are required



Reed Sensors – N.C. (Normally Closed)

- A magnet is centered over the contacts closing the contacts
- Another magnet is mounted to a moving element where its distance is being sensed
- Magnet entering reed switch's sphere of magnetic influence will open the contacts
- Removing the second magnet will cause the contacts to reclose completing the cycle



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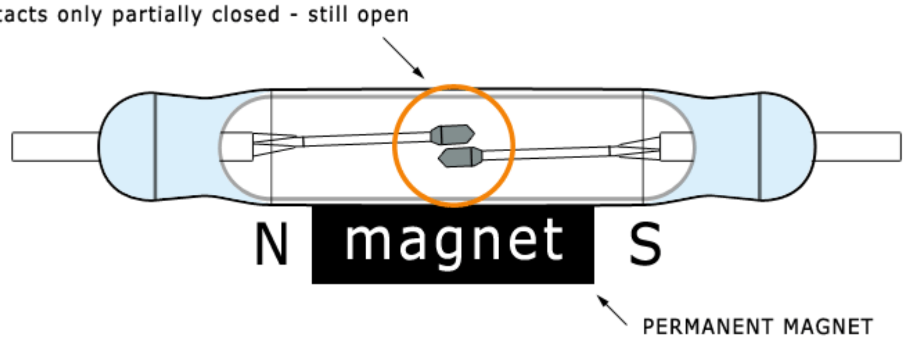
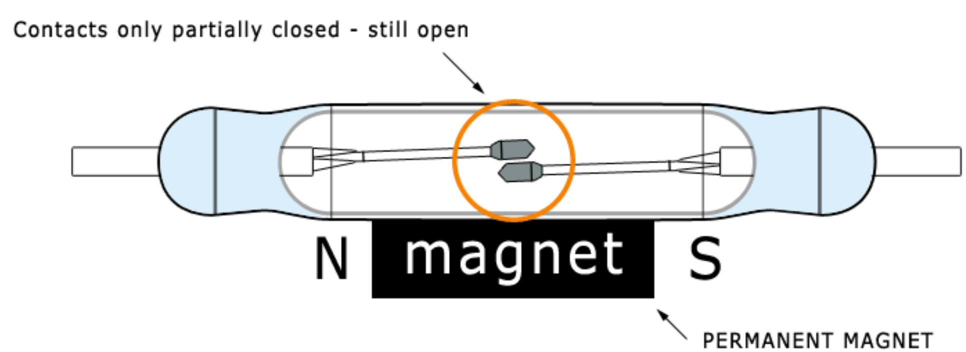
Reed Sensors – Latching

- Again a magnet is centered over the contacts
- The magnet's strength is not strong enough to close the contacts
- A second magnet is mounted to a moving element where its distance is being sensed
- When this second magnet enters reed switch's sphere of magnetic influence the contacts will close
- Removing the second magnet the contacts will remain closed



Reed Sensors – Latching

- A third magnet with opposite polarity to the second magnet is used
- Also, one can use the second magnet with its polarity reversed
- When this magnet enters reed switch's sphere of magnetic influence the contacts will open
- Removing this magnet the contacts will remain open completing the cycle



Summary

Magnets have unique properties in electronics

Wide variety of magnets with host of different properties

Magnet usage is increasing in electronic applications

They allow us to switch reed sensors with zero power.

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