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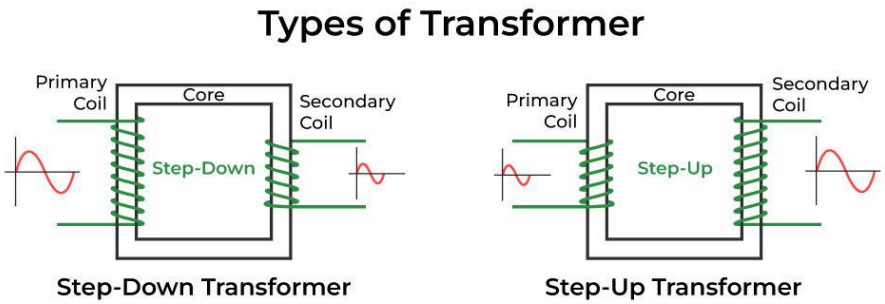
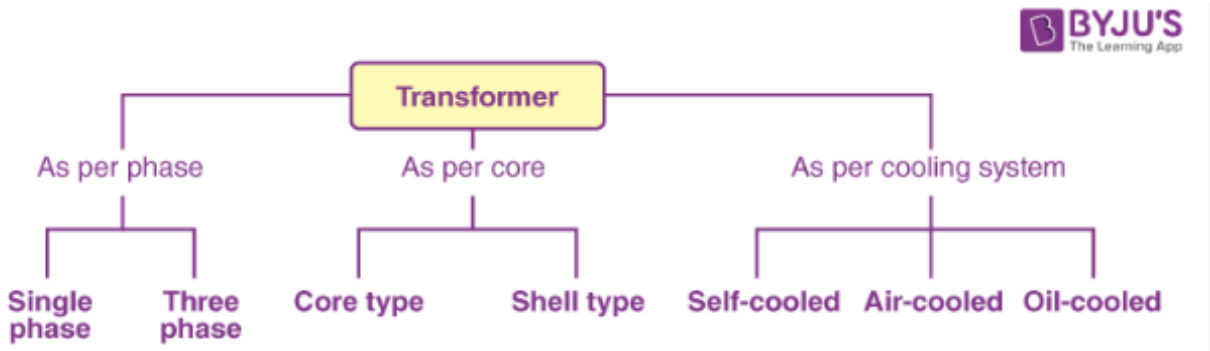
TASK – 3

TRANSFORMER

- **DEFINITION** : Transformer, device that transfers electric energy from one alternating-current circuit to one or more other circuits, either increasing (stepping up) or reducing (stepping down) the voltage.
  The transformer works on the basic principles of electromagnetic induction and mutual induction.

- **Transformer Types** :





1. ***Based on Voltage Levels*** : Commonly used transformer types, depending on the voltage, are classified as follows:

a. *Step-up Transformer*: They are used between the power generator and the power grid. The secondary output voltage is higher than the input voltage.

b. *Step-down Transformer*: These transformers are used to convert high-voltage primary supply to low-voltage secondary output.

2. ***Based on the Medium of Core Used***: In a transformer, we will find different types of cores that are used.

a. *Air Core Transformer*: The flux linkage between primary and secondary winding is through the air. The coil or windings wound on the non-magnetic strip.

b. *Iron Core Transformer*: Windings are wound on multiple iron plates stacked together, which provides a perfect linkage path to generate flux.

3. ***Based on the Winding Arrangement*** :

a. *Autotransformer*: It will have only one winding wound over a laminated core. The primary and secondary share the same coil. Auto means “self” in the Greek language.

4. ***Based on Install Location*** :

a. *Power Transformer*: It is used at power generation stations, as they are suitable for high voltage application.

b. *Distribution Transformer*: It is mostly used at distribution lanes for domestic purposes. They are designed for carrying low voltages. It is very easy to install and characterised by low magnetic losses

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5. ***Measurement Transformers***: They are mainly used for measuring voltage, current and power.

6. ***Protection Transformers***: They are used for component protection purposes. In circuits, some components must be protected from voltage fluctuation, etc. Protection transformers ensure component protection.

- **Working Principle of a Transformer :**

The transformer works on the principle of Faraday’s law of electromagnetic induction and mutual induction.

There are usually two coils – primary coil and secondary coil – on the transformer core. The core laminations are joined in the form of strips. The two coils have high mutual inductance. When an alternating current passes through the primary coil, it creates a varying magnetic flux. As per Faraday’s law of electromagnetic induction, this change in magnetic flux induces an EMF (electromotive force) in the secondary coil, which is linked to the core having a primary coil. This is mutual induction.

- **FUNCTIONS OF TRANSFORMERS**

1. Transfer of electrical energy from one circuit to another.
2. Transfer of electrical power through electromagnetic induction.
3. Electric power transfer without any change in frequency.
4. Two circuits are linked with mutual induction.

- **APPLICATIONS OF TRANSFORMERS :**

1. ***Power generation***: Transformers increase the voltage of electricity generated by power plants before it is sent to the grid.
2. ***Battery charging***: Transformers maintain the voltage so that internal battery components are not damaged.
3. ***Steel manufacturing***: Transformers provide high currents for melting and welding steel, and lower currents for cooling.
4. ***Lighting***: Single-phase transformers provide power for residential lighting.
5. ***Heating***: Single-phase transformers provide power for heating.
6. ***Air conditioning***: Transformers step down high voltages to lower voltages for household appliances like air conditioners.

RELAYS

- **DEFINITION** : A relay is an electrically operated switch that uses an electromagnet to open or close a circuit. Relays are typically controlled by electrical signals, while switches can be activated manually.

- **WORKING :**

1. A relay has a set of input terminals for one or more control signals.

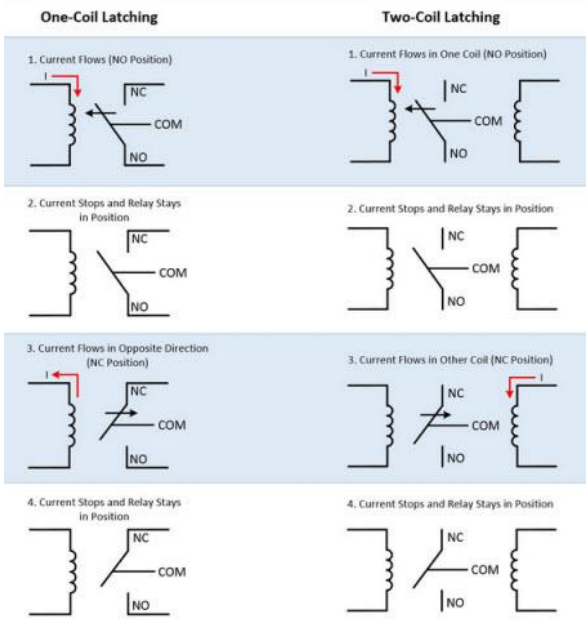
2. The relay receives an electrical signal and sends it to other equipment by turning the switch on and off.

3. The relay's electromagnet is a coil of wire that becomes a temporary magnet when electricity flows through it.

4. The relay uses a relatively small electric current to turn on or off a much larger electric current.

- **TYPES :**

1. ***Latching Relays :*** A Latching Relay is a relay which maintains its state after being actuated. That is why these types of relays are also called as Impulse Relays or Keep Relays or Stay Relays. In applications, where there is a need to limit the power consumption and dissipation, a latching relay is best suitable.



2. ***Reed Relays*** : Similar to the electromechanical relays, reed relays also produce the mechanical actuation of physical contacts to open or close a circuit path. However, compared with electromagnetic relays these relay contacts are much smaller and have low mass.

3. ***Differential Relays*** : Differential Relays are those relays which work on the 'difference' of the controlling (or actuating) signals. Differential Relays operate when the phasor difference of two or more similar electrical quantities exceeds a predetermined value

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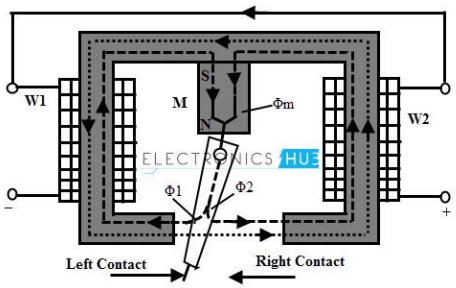
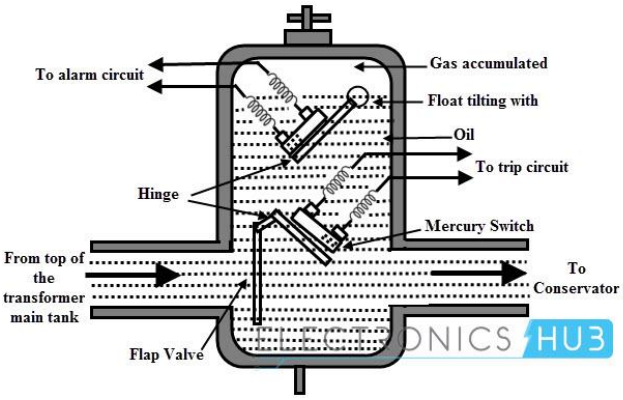
4. ***Polarized Relays*** : these relays are very sensitive to the direction of current by which it is energized. It is a type of DC electromagnetic relay provided with an additional source of permanent magnetic field to move the armature of the relay. In these relays, magnetic circuit is built with permanent magnets, electromagnets and an armature.



5. ***Buchholz Relays*** : These relays are gas operated or actuated relays. These relays are used to detect incipient faults (or internal faults which are minor faults initially but in due course of time they turn into major faults).



6. ***Overload Protection Relays*** : Overload protection relays are specially designed to provide the overcurrent protection of electrical motors and circuits. These overload relays can be of different types such as fixed bimetallic strip type, electronic or interchangeable heater bimetallic, etc.

7. ***Solid State Relays*** : Solid state relays use solid state components such as BJTs, thyristors, IGBTs, MOSFETs and TRIACs to perform the switching operation. The power gain of these relays is much higher than the electromechanical relays because the control energy required (to power the control circuit) is much lower compared with power to be controlled (switching output) by these relays. These relays can be designed to work for both AC and DC supply.

SSRs are classified into different types, however major types of these relays include photo-coupled SSRs and transformer coupled SSRs

a. In transformer coupled SSR, a small DC current is supplied to the primary of the transformer through a DC to AC converter.

b. In case of photo coupled SSRs, photosensitive semiconductor device is used for performing the switching operation.

8. Inverse Definite Minimum Time Relays (IDMT Relays)

This type of relay gives a definite-time current characteristic at higher values of the fault current and an inverse time current characteristic at lower values of the fault current. These are widely used for protection of distribution lines and they offer to set the limits for current and time settings.

9. Safety Relays
10. Ground Fault Relays
11. Distance Relays
12. Small Signal Relays
13. Time Delay Relays
14. Multi-Dimensional Relays
15. Thermal Relays
16. Rotary Relays
17. Sequence Relays
18. Moving Coil Relays
19. Electronic Relays
20. Non-Latching Relays
21. Electromagnetic Relays
22. Automotive Relays

- **APPLICATIONS :**

1. Lighting control systems
2. Telecommunication systems
3. Traffic control systems
4. Electrical power protection systems
5. Automotive home appliances systems
6. Electrical drive control
7. Industrial process control systems
8. DIY projects
9. Motor control
10. Automotive applications, such as electrical fuel pumps
11. Industrial applications where control of high voltages and currents is intended
12. Controlling large power loads
13. Control panels
14. Manufacturing
15. Building automation

OPTOCOUPLER

- **DEFINITON :** Optocouplers are semiconductor devices that transfer a signal from one electrical circuit to another while providing electrical isolation.

  They are used in communications, control, and monitoring systems where data signals could provide a point of ingress for harmful voltages to damage a device

- **WORKING:**

An optocoupler has two parts: an LED that emits infrared light and a photosensitive device that detects the light.

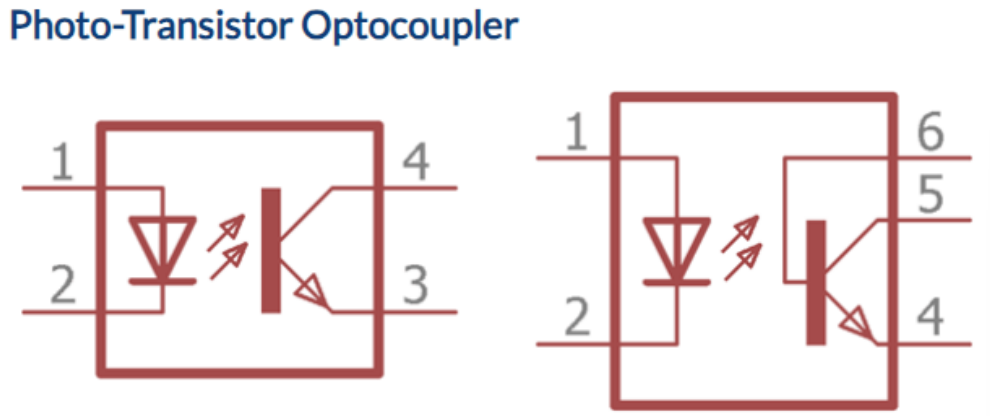
The LED and photosensitive device are separated from each other in proximity.

When the LED turns on, the light hits the photosensitive device, allowing current to flow in the secondary circuit.

Optocouplers prevent high voltages from affecting the system receiving the signal.

TYPES :

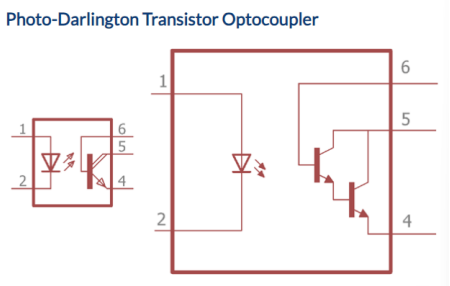
1.***Opto-coupler which use Photo Transistor*** :



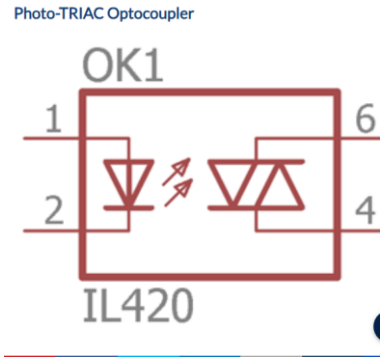
In the upper image the internal construction is shown inside a Photo-transistor Optocoupler. The Transistor type can be anything whether PNP or NPN.

Photo-Transistor can be further of two types depending on the output pin availability. On the second image on the left, there is additional pin out which is internally connected with transistor's base. This pin 6 is used to control the sensitivity of the photo-transistor. Often the pin is used to connect with ground or negative using a high value resistor. In this configuration, false triggering due to noise or electrical transients can be controlled effectively.

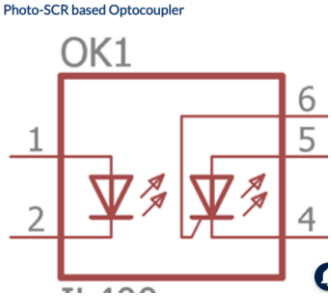
2***. Opto-coupler which use Photo Darlington Transistor*** :This type of opto-coupler also used in DC circuit related area for the isolation. The 6th pin which is internally connected to the base of the transistor, used to control the sensitivity of the transistor as discussed previously in photo-transistor description.



3.***Opto-coupler which use Photo TRIAC*** : TRIAC is mainly used where AC based control or switching is needed. The led can be controlled using DC, and the TRIAC used to control AC. Opto-coupler provide excellent isolation in this case too.



4.***Opto-coupler which use Photo SCR*** : SCR stand for Silicon controlled rectifier, SCR also referred as Thyristor.Same as like other opto-coupler the LED emit Infrared. The SCR is controlled by the intensity of the LED. Photo-SCR based Opto-coupler used in AC related circuitry.

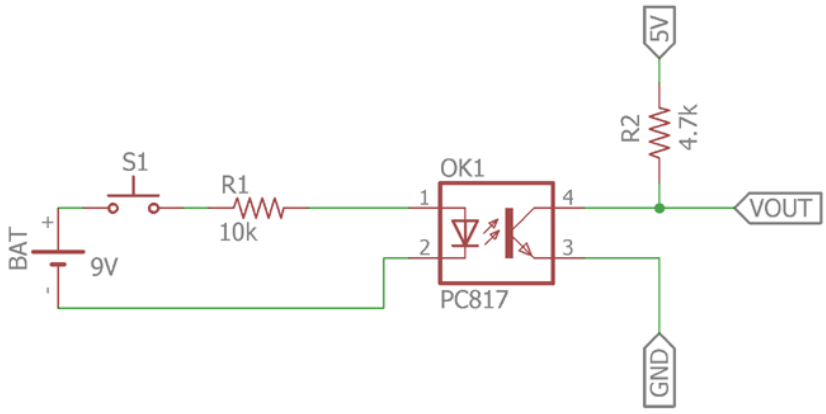


- **APPLICATIONS :**

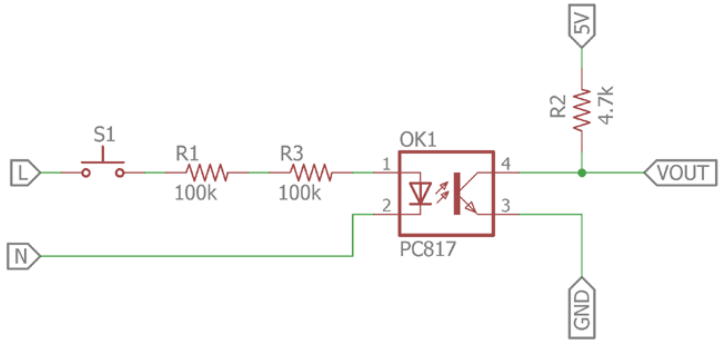
1. ***Switching***: Optocouplers can be used as a switching device.
2. ***Isolation***: Optocouplers can provide isolation between low and high-voltage circuits.
3. ***Sensing***: Optocouplers can be used to sense zero-crossing of AC power mains. They can also be used in sensor applications to sense the presence of physical objects.
4. ***Control***: Optocouplers can be used for DC and AC power control.
5. ***Detection***: Optocouplers can be used for tape-position detection, engine-shaft revolution counting, or speed measurement.

Few Optocoupler used in DC circuit and few Optocoupler used in AC related operations. As the Optocoupler does not allow direct electrical connection between two sides, the main application of the Optocoupler is to isolate two circuits.

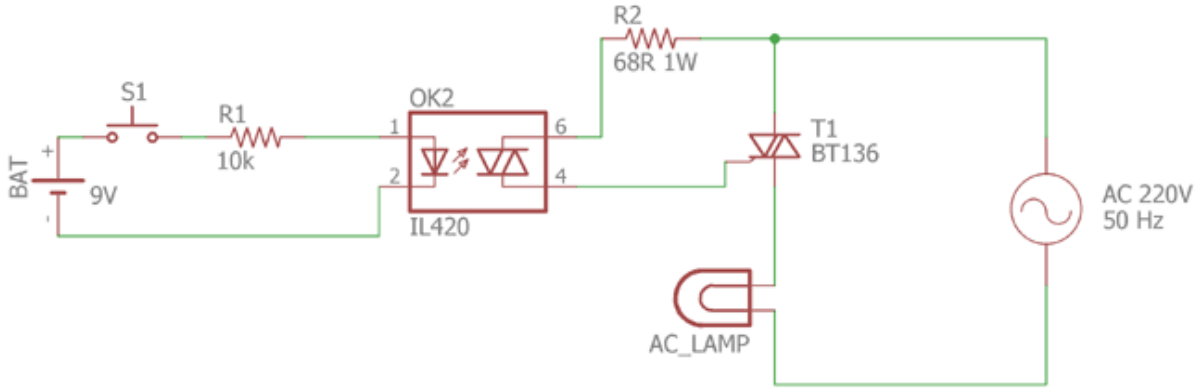
1.***Optocoupler for Switching DC Circuit*** : In the upper circuit a Photo-Transistor based optocoupler circuit is used . It will act like a typical Transistor switch.



2.***Optocoupler for Detecting AC Voltage*** : In this configuration the opto-coupler can be connected across low voltage circuit such as microcontroller unit where the AC voltage detection is required. The output will produce square High to Low pulse.



3.***Optocoupler for Controlling AC Circuit using DC voltage*** : This type of configuration is used to control electrical appliances using low voltage circuitry.



Other than this type of circuitry an opto-coupler can be used in SMPS to sending secondary side short-circuit or over current condition information to the primary side.

VOLTAGE REGULATOR

DEFINITON : A voltage regulator is a circuit that creates and maintains a fixed output voltage, irrespective of changes to the input voltage or load conditions.

Voltage regulators (VRs) keep the voltages from a power supply within a range that is compatible with the other electrical components. While voltage regulators are most commonly used for DC/DC power conversion, some can perform AC/AC or AC/DC power conversion as well.

- **TYPES**

  There are two main types of voltage regulators: linear and switching. Both types regulate a system's voltage, but linear regulators operate with low efficiency and switching regulators operate with high efficiency. In high-efficiency switching regulators, most of the input power is transferred to the output without dissipation.

  1.***Linear Regulators*** : A linear voltage regulator utilizes an active pass device (such as a BJT or MOSFET), which is controlled by a high-gain operational amplifier. To maintain a constant output voltage, the linear regulator adjusts the pass device resistance by comparing the internal voltage reference to the sampled output voltage, and then driving the error to zero.

  Linear regulators are step-down converters

2.***Switching Regulators :*** A switching regulator circuit is generally more complicated to design than a linear regulator, and requires selecting external component values, tuning control loops for stability, and careful layout design. Switching regulators can be step-down converters, step-up converters, or a combination of the two, which makes them more versatile than a linear regulator.

- ***LDO Regulators :*** One popular topology for linear regulators is a low-dropout (LDO) regulator. Linear regulators typically require the input voltage to be at least 2V above the output voltage. However, an LDO regulator is designed to operate with a very small voltage difference between input and output terminals, sometimes as low as 100mV.

- ***Step-Down and Step-Up Converters :*** Step-down converters (also called buck converters) take a larger input voltage and produce a lower output voltage. Conversely, step-up converters (also called boost converters) take a lower input voltage and produce a higher output voltage.

- ***Buck-Boost Converters :***A buck-boost converter is a single-stage converter that combines the functions of a buck and a boost converter to regulate the output over a wide range of input voltages that can be greater or less than the output voltage.

APPLICATIONS :

- ***Motor vehicles:*** Match the output voltage of the generator to the electrical load and to the charging requirements of the battery

- ***Electronic equipment***: Used in equipment where excessive variations in voltage would be detrimental.

- ***Power supplies***: Provide the desired output voltage for computers, televisions, laptops, and other devices.

- ***Small electronic circuits***: Rely on regulators to operate.

- ***Mobile chargers***: Provide a constant voltage.

- ***Audio and radio frequency amplifiers***: Provide a stable and consistent voltage supply.

- ***Computers***

- ***Alternators***

- ***Power generator plants***

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