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IMPLEMENTATION OF INTEGRATED SEPIC FLYBACK CONVERTER FOR LED DRIVE WITH EFFICIENT POWER FACTOR

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Abstract - The abstract describes an integrated SEPIC-Fly back converter designed for LED drive applications with an efficient power factor. A SEPIC converter is a type of DC-DC converter that can step up or step down the input voltage, while a Fly back converter is a transformer-based converter that can provide galvanic isolation. By integrating both converters, the proposed design can achieve both functions with high efficiency. LEDs require a constant current for optimal performance, and the proposed converter can regulate the output current while maintaining a high-power factor. Power factor is a measure of how effectively the converter utilizes the AC power from the input source, and a high-power factor means that less energy is wasted. The integrated converter is designed using a arduiono to control the power stage, and a prototype is built and tested to verify the performance. The results show that the converter achieves a high efficiency and power factor, making it suitable for LED drive applications.

Keywords: LED drive applications, LED drive, SEPIC converter, fly back converter, galvanic isolation

I. INTRODUCTION

LEDs have grown in popularity in recent years because to their low cost, high brightness, extended lifetime, energy efficiency, and high efficiency. When an electric current run across it, a semiconductor device emits light. It generates various colours such as white, yellow, red, and green. Gallium Arsenide (GaAs) and Gallium Phosphide (GaP) are two semiconductor materials often utilised to create LEDs are powered by a DC power supply. Rectifiers are used to convert alternating current to direct current. Various converters are used to increase or decrease the output voltage and improve the power factor of the LED drive. To reduce inductor ripple current, a Buck Boost converter is utilized [1]. It runs in pseudo-continuous mode. This approach produces little current ripple; however, it is not ideal for light loads due to its low efficiency. An isolated CUK converter is used to reduce total harmonic distortion (THD) over a wide range of load variations [2]. It uses the current and voltage loops as the inner and outer loops, respectively. The low THD of the input current is an advantage of this technology, althoughLEDs. The anode and cathode terminals of an LED are connected to the voltage source. The colour of the light is determined by the energy band gap. LEDs are utilized in street lighting, automobile illumination, ornamental lighting, TV backlighting, and other applications Switches are used to control the converter. In the Switches are used to control the converter. In the circuit, these switches cause switching losses. A capacitor-less high power factor LED drive with buck converter is presented, featuring two parallel channels for power transfer [9]. As a result, switching losses are significant. To reduce switching losses, a two-stage LED drive with buck boost and buck converter is proposed [3]. Only two switches are employed here, and it functions in zero voltage switching mode (ZVS). THD and switching losses have both been decreased. However, this technique necessitates the addition of more components to the circuit. Another technique to reduce switching losses is to use zero current switching. circuit, these switches cause switching losses. A buck converter and capacitor-less high-power factor LED drive are suggested, using two parallel routes created to transfer authority. Due to this, switching losses are substantial. A two-stage LED drive with buck boost and buck converter is proposed in order to reduce switching losses. Here, only two switches are utilized, and zero voltage switching condition (ZVS) is used to operate. Switching losses and THD have decreased. But the

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circuit for this system needs more parts. Operating with zero current switching is an alternative strategy for reducing switching losses.To lessen switching loss, an LED drive with a class E converter is run in zero current switching. Due to the electrolytic capacitor being present in the circuit, dependability is decreased. Utilising high power factor converters with less dc link capacitance can increase dependability. Here, a boost converter with coupled inductance and series inductance is used to extend the life of the LED drive.

An integrated bridgeless boost converter with a non-resonant half bridge converter that operates in discontinuous conduction has switching losses. This approach is appropriate for street lighting and retrofit lamp applications, but not for high load variations.

II. LITEATURE SURVEY

1)High-Efficiency Two-Switch Tri-State Buck-Boost Power Factor Correction Converter With Fast Dynamic Response And Low-Inductor Current Ripple

This paper proposes and analyses a two-switch tri-state buck-boost power factor correction (PFC) converter operating in pseudo-continuous conduction mode. The suggested two-switch tri-state buck-boost PFC converter, unlike the tri-state boost PFC converter, does not require an additional power switch to provide an additional degree of control freedom. As a result, unlike tri-state boost PFC converters, it does not add complexity and has no effect on power conversion efficiency.

2)Digital Control of Isolated Cuk Power Factor Correction Converter Under Wide Range O F Load Variation

The abstract describes a digital control system for an isolated Cuk PFC converter that can function under a wide range of load changes. The Cuk converter is a sort of DC-DC converter that may step up or step down the input voltage while offering input-output isolation. PFC is a technique used to improve the power factor of AC-DC converters, which is a measurement of how efficiently the converter uses the alternating current power from the input source. A high power factor ensures that less energy is wasted, which leads to greater efficiency and lower utility bills. The isolated Cuk PFC converter may provide high power factor correction while providing input and output isolation.

3)Design And Implementation Of A High-Power factor Led Driver W Ith Zero-Voltage Switching on Characteristics

The abstract describes the design and implementation of a high-power factor LED driver with zero-voltage switching (ZVS) characteristics. The LED driver is a type of DC-DC converter that can regulate the current and voltage to the LED load. Power factor is a measure of how effectively the converter utilizes the AC power from the input source. A high power factor means that less energy is wasted, resulting in higher efficiency and lower utility bills. The proposed LED driver is designed to achieve high power factor correction while also providing ZVS characteristics**.**

ZVS is a technique used in power electronics to reduce switching losses and improve efficiency. By designing the LED driver with ZVS characteristics, it can switch the power devices at zero voltage, minimizing the switching losses and increasing the efficiency. The proposed LED driver is implemented using a resonant LLC topology, which is a type of DC-DC converter that can provide high efficiency and ZVS characteristics. The resonant LLC topology uses resonant tank circuits to regulate the output voltage and current, reducing switching losses and improving efficiency. A prototype of the LED driver is built and tested to verify the performance. The results show that the LED driver achieves high power factor correction and ZVS characteristics, resulting in high efficiency and low harmonic distortion. Therefore, the proposed LED driver can be suitable for various LED lighting applications, including indoor and outdoor lighting, as well as street lighting

4) Switching noise is decreased in street light applications by using a power factor correction converter [6].

However, the mechanism is more complicated. The electrolytic capacitor's weakness and electromagnetic interferences are overcome by utilising a series-resonant converter (SRC) as power factor control (RFC) The conduction loss is greater here.

5)Design and Implementation Of A High-Power factor Led Driver W Ith Zero-Voltage Switching on Characteristics

It's a novel LED driver composed of a buck-boost converter and a buck converter. Each converter 8's active switch is a power MOSFET. By freewheeling the inductor current of the converters through the intrinsic diodes of the MOSFETS, both active switches can operate at zero-voltage switching on (ZVS) without the use of any auxiliary switches or snubber circuits.

6)Single-Stage High Power Factor Converters Requiring Low Dc-Link Capacitance To Drive Power Led

The abstract describes single-stage high power factor converters with minimal DC-link capacitance that may drive power LEDs. For maximum performance, power LEDs require a constant current, and the suggested converters can adjust the output current while retaining a high-power factor, Power factor is a measure of how well the converter uses the alternating current power from the input source. A high-power factor ensures that less energy is wasted, which leads to greater efficiency and lower utility bills. By combining the rectification and power factor correction functions into a single stage, the single-stage converter achieves excellent power factor correction. The suggested converters employ a current-fed push-pull topology, which allows for high efficiency and minimal input current harmonics. The low DC-link capacitance requirement is met by employing.

III. PROPOSED SYSTEM

In proposed system SEPIC fly back converter topology is designed high power factor correction The abstract covers a power factor correction (PFC) SEPIC (Single-Ended Primary Inductance Converter) converter with a fly back architecture. The suggested converter is a hybrid of two well-known DC-DC converter topologies that can provide high power factor correction and efficiency. Power factor adjustment is required to ensure that electrical equipment runs efficiently and that harmonic distortion in the power supply is reduced. By combining a SEPIC converter for voltage regulation with a flyback converter for energy transfer, the suggested converter achieves high power factor correction. The SEPIC converter is used to regulate the output voltage and keep the output current constant. Power factor correction requires the employment of a flyback converter to move energy from the input to the output. The marriage of these two topologies.

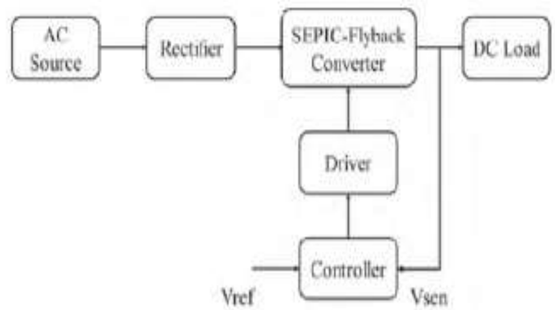

Figure 1: SEPIC with flyback converter topology

1)Advantages

- High power factor correction
- Reduced switching loss
- Power loss reduction

2)Mathematical model for SEPIC flyback converter

A SEPIC-flyback converter can be modeled mathematically using a set of equations that describe the relationships between the converter's input and output variables. The following is a basic mathematical model for a SEPIC-flyback converter: Relationship between input and output:

V_out = D x (1 - D) x V_in - Np/Ns x V_flyback

where output voltage is V_out D stands for the converter's duty cycle. input voltage, V_in Np is the flyback transformer's primary turn count. Ns in the flyback transformer stands for the number of secondary turns. Voltage across the flyback transformer is V_flyback.

Inductor Current: (1 - D) x (i_in) = i_L

i_L is the inductor current where

i_in = Current input

Voltage of the output: V_out = R x i_out + V_flyback. R is the load resistance where The behavior of the SEPIC-flyback converter can be

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predicted and optimised for particular applications by resolving these equations. To achieve the desired output voltage and current while retaining high efficiency and power factor correction, several factors, including duty cycle, inductance, and capacitance values, can be changed.

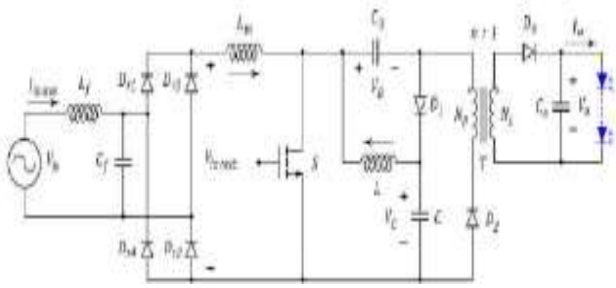
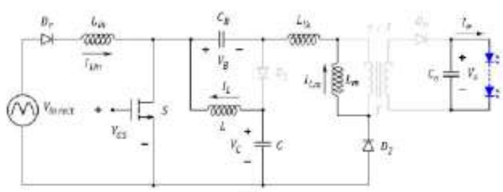


Figure: circuit diagram for LED

3)MODES OF OPERATION

The SEPIC-flyback converter operates in four modes, which are based on the switching states of the two switches (S1 and S2) and the diodes (D1 and D2) in the circuit. The four modes of operation are as follows:



(a)

Figure:3 mode 1 operation

1) Mode 1: S1 and D1 are ON, S2 and D2 are OFF: In this mode, the input voltage is applied to the primary side of the flyback transformer, and the inductor current increases. The output voltage is regulated by the duty cycle of the SEPIC converter, and the flyback transformer stores energy in its primary winding.
2) Mode 2: S1 and D1 are OFF, S2 and D2 are ON In this mode, the energy stored in the flyback transformer's primary winding is transferred to the secondary winding and the output capacitor. The output voltage increases until it reaches the setpoint, and the inductor current decreases**.**

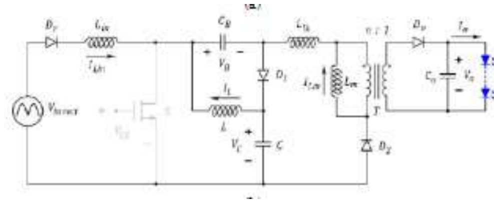


Figure 4: mode 2 current flowing

3) Mode 3: S1 is ON, D1 is OFF, S2 and D2 are OFF

In this mode, the voltage across the inductor reverses, and the energy stored in the flyback transformer's primary winding is transferred to the output capacitor. The voltage across the flyback transformer's secondary winding is negative, and the diode D2 is reverse-biased.4. Mode 4: S1 is OFF, D1 is ON, S2 and D2 are OFF In this mode, the energy stored in the output capacitor is used to maintain the output voltage, and the inductor current decreases further. The diode D1 is reverse-biased, and the voltage across the flyback transformer's primary winding is zero. The operation of the SEPIC-flyback converter depends on the switching frequency, duty cycle, and load conditions. The controller adjusts these parameters to regulate the output voltage and maintain high efficiency and power factor correction.

(b)

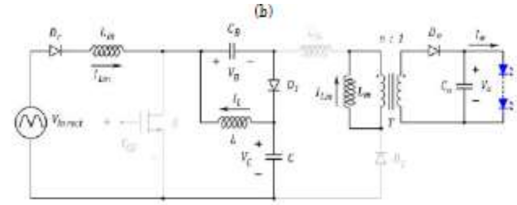


Figure5: model 3 flow diagram

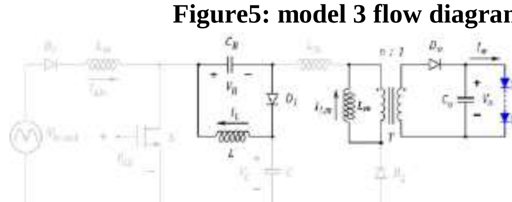


Figure 6: mode 4 current flow diagram

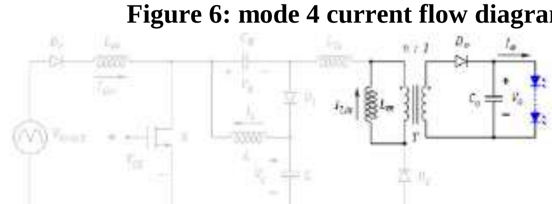


Figure 7: mode 5 current flow diagram

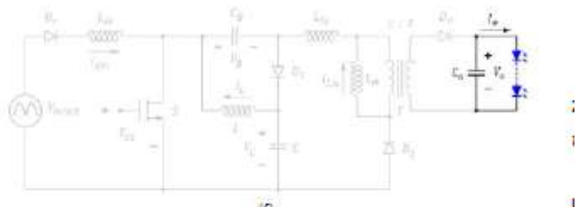


Figure8: mode 6 current flow diagram

IV. SIMULATION AND EXPERIMENTAL RESULT

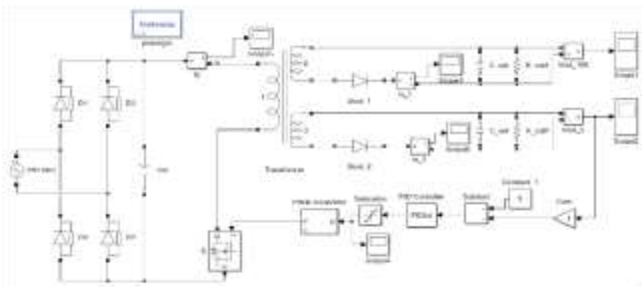


Figure 1: simulation figure

parameter	Variable	value
Arduino controller	at mega 328 microcontroller	
Inductor	uh	6.4 uh
Capacitor	uf	3uf
Resistor	Resistor	10k
Diode		In4007
Input voltage	voltage	12
Output voltage	voltage	24

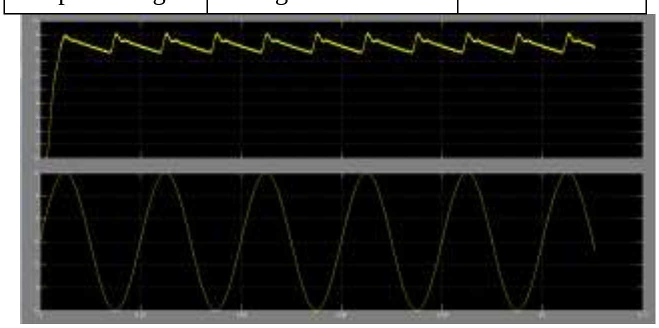


Figure 2: output waveform

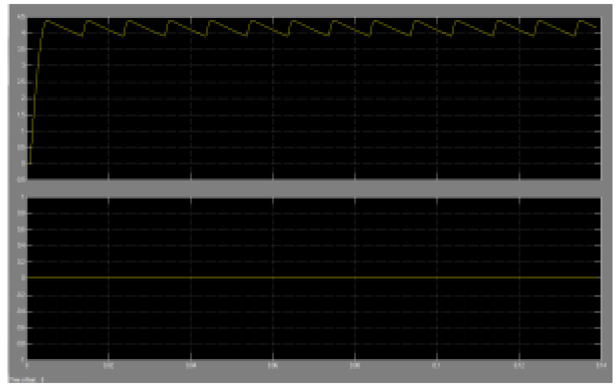


Figure 3: input and output voltage

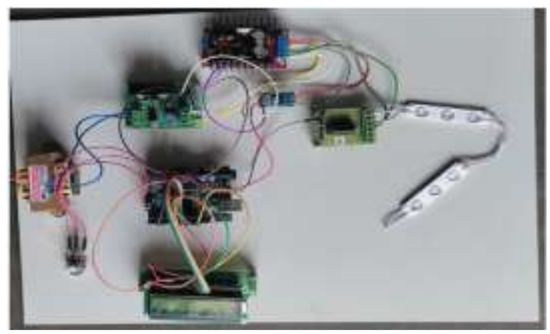
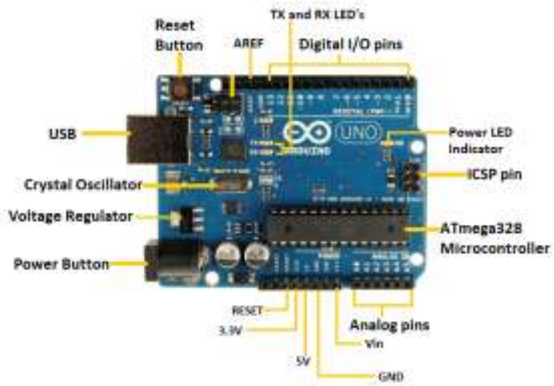


Figure 4: hardware setup diagram

1)ARDUINO UNO

The Arduino UNO is a standard Arduino board. In this context, UNO denotes 'one' in Italian. The original release of Arduino Software was labelled as UNO. It was also the first USB board made available by Arduino. It is regarded as a powerful board that is employed in a variety of tasks. The Arduino UNO board was created by Arduino.cc. The Arduino UNO is built on the ATmega328P microprocessor. In comparison to other boards, such as the Arduino Mega, it is simple to use. The board is made up of digital and analogue I/O pins, shields, and other circuitry. The Arduino UNO has six analogue input pins, fourteen digital pins, a USB connection, a power jack, and an ICSP (In-Circuit Serial Programming) header. It's written in IDE, which stands for Integrated Development Environment. It is compatible with both online and offline platforms.

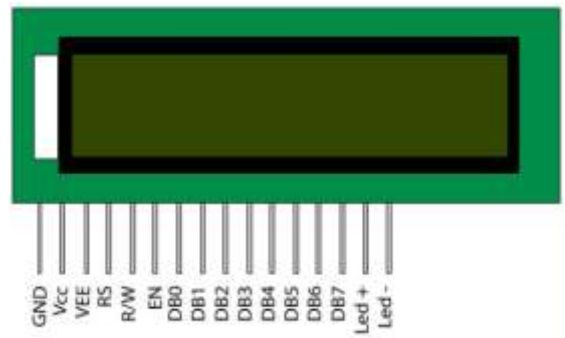


2)PINSGeneral Pin functions

- LED: There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- VIN: The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 20V), the USB connector (5V), or the VIN pin of the board (7-20V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.
- 3V3: A 3.3 volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND: Ground pins.
- IOREF: This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.
- Reset: Typically used to add a reset button to shields which block the one on the board.

3)LCD DISPLAY

LCD is an abbreviation for liquid crystal display. It is a type of electronic display module that is used in a wide variety of applications such as various circuits and devices such as mobile phones, calculators, computers, TV sets, and so on. These displays are mostly used for light-emitting diodes with multiple segments and seven segments. The primary advantages of adopting this module are that it is affordable, easily configurable, has no constraints for displaying unique characters, special and even animations.



- Pin1 (Ground/Source Pin): This is a GND pin of display, used to connect the GND terminal of the microcontroller unit or power source.
- Pin2 (VCC/Source Pin): This is the voltage supply pin of the display, used to connect the supply pin of the power source.
- Pin3 (V0/VEE/Control Pin): This pin regulates the difference of the display, used to connect a changeable POT that can supply 0 to 5V.
- Pin4 (Register Select/Control Pin): This pin toggles among command or data register, used to connect a microcontroller unit pin and obtains either 0 or 1(0 = data mode, and 1 = command mode).
- Pin5 (Read/Write/Control Pin): This pin toggles the display among the read or writes operation, and it is connected to a microcontroller unit pin to get either 0 or 1 (0 = Write Operation, and 1 = Read Operation).
- Pin 6 (Enable/Control Pin): This pin should be held high to execute Read/Write process, and it is connected to the microcontroller unit & constantly held high.
- Pins 7-14 (Data Pins): These pins are used to send data to the display. These pins are connected in two-wire modes like 4-wire mode and 8-wire mode. In 4-wire mode, only four pins are connected to the microcontroller unit like 0 to 3, whereas in 8-wire mode, 8-pins are connected to microcontroller unit like 0 to 7.
- Pin15 (+ve pin of the LED): This pin is connected to +5V

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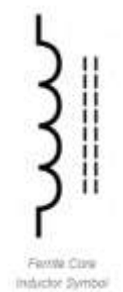
- Pin 16 (-ve pin of the LED): This pin is connected to GND.

4)FERRITE CORE INDUCTOR

Ferrite core inductors are inductors that have a ferrite core inside their coil. Because of the electrical conductivity of the metal, when these solid metal cores are employed in inductors, the changing magnetic field produces enormous eddy currents. Along with the closed-loop of electric current, these currents cycle within the inductors. Inductors with ferrite cores are utilised in a variety of electric circuit applications such as power conversion, broadband, and interference suppression.



In 2000 volts primary / secondary insulation 60°C ambient temperature For reinforced insulation, the construction complies with IEC950, IEC335, and IEC61558. UL94-V0 listed materials are used exclusively. A ferrite core inductor is a type of inductor that increases its inductance by using a ferrite core. When an electric current flows through an inductor, it stores energy in the form of a magnetic field. An inductor's inductance is proportional to the number of wire turns in the coil and the permeability of the core material.A ferrite core inductor is made out of a wire coil wrapped around a ferrite core. Ferrite is a ceramic substance with high permeability but poor electrical conductivity. The ferrite core boosts the coil's inductance by providing a low reluctance channel for the magnetic field to pass through. Because of the high permeability of the ferrite core, the inductor can store more magnetic energy for a given amount of current. Because of their great performance and small size, ferrite core inductors are commonly employed in electronic circuits. They're frequently found in power supply, filters, and signal processing circuits. Ferrite core inductors come in a variety of sizes and forms to suit a variety of applications.

The inductance of a ferrite core inductor is determined by the number of turns of wire in the coil, the wire diameter, and the permeability of the ferrite core. The following formula may be used to determine inductance:

$L = (N^2 * \mu * A)/L$

Where:

L = inductance in henries (H)

N = number of turns

μ = permeability of the core material

A = cross-sectional area of the core

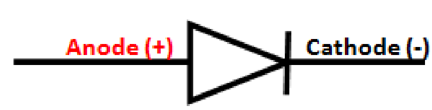
l = length of the core

Ferrite core inductors can be purchased with pre-calculated inductance values, or they can be custom-made to meet specific requirements.

Figure: Ferrite core inductor

5)DIDOE IN4007

A diode is a device that only enables current to flow in one direction. In other words, current should always travel from anode to cathode. A grey bar, as illustrated in the image above, identifies the cathode terminal. The maximum current carrying capability of the 1N4007 diode is 1A, and it can endure peaks of up to 30A. As a result, we may utilise this in circuits designed for less than 1A. The reverse current is just 5uA, which is insignificant. This diode has a power dissipation of 3W.



6) STEP DOWN TRANSFORMER

A step-down transformer is one that has a higher number of turns in the primary winding and a lesser number in the secondary winding. As we can see from the preceding calculation for the relationship between the number of turns in winding and voltage,

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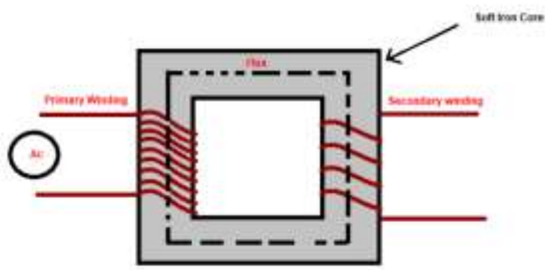
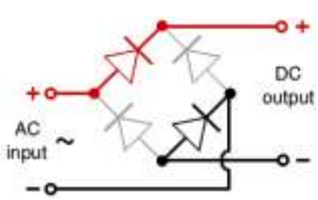
if the number of turns in the primary is more than the number of turns in the secondary, the EMF generated in the secondary is less than the primary input. As a result, the secondary coil of a step-down voltage transformer has a lower voltage. The step-down transformer, as the name implies, is used to convert higher voltage electricity to lower voltage power.



7) RECTIFIER

The rectifier circuit is used to convert AC (Alternating Current) to DC (Direct Current). Rectifiers are grouped into three types: half-wave, full-wave, and bridge rectifier. The primary job of all of these rectifiers is to convert current, although they do not do so effectively. Both the centre tapped full wave rectifier and the bridge rectifier convert well. A bridge rectifier circuit is a ubiquitous component of electronic power systems. Many electronic circuits require a rectified DC power source to power the numerous electronic fundamental components from an available AC mains supply. This rectifier may be found in a broad range of electronic AC power devices, including household appliances, motor controllers, modulation processes, welding applications.



8) VOLTAGE SENSOR

This sensor measures, calculates, and determines the voltage supply. This sensor can detect the amount of AC or DC voltage. This sensor's input can be voltage, and its output can be switches, analogue voltage signals, current signals, audio signals, and so on. Some sensors provide outputs such as sine waveforms or pulse waveforms, while others can create outputs such as AM (Amplitude Modulation), PWM (Pulse Width Modulation), or FM (Frequency Modulation). The voltage divider can affect the measurement of these sensors.A simple but very useful module which uses a potential divider to reduce any input voltage by a factor of 5. This allows you to use the analogue input of a microcontroller to monitor voltages much higher than it capable of sensing. For example, with a 0-5V analogue input range you are able to measure a voltage up to 25V. The module also includes convenient screw terminals for easy and secure connection of a wire.

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