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DESIGN AND IMPLEMENTATION OF CURRENT CONTROL FOR POWER CONVERTER USING HALL EFFECT SENSOR

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ABSTRACT:

In this paper a new method for current and voltage sensing in power electronic converters is demonstrated. This concept which uses the converter's own electromagnetic interference, associates an electromagnetic field characterization method and PID control. These two combined with a circuit analysis allow the prediction of the needed parameters to achieve the current programmed control chosen here. Results obtained on a Buck-Boost converter show the feasibility of this concept.

1. Introduction

Around 40 percent of the world's power needs are currently met by electrical energy and that proportion is expected to rise as countries cut carbon emissions and shift to renewable energy sources. As the trend towards electrification and renewable energies increases, enabling technologies such as power electronics are becoming ever more important. Power electronics is an umbrella term that encompasses the systems and products involved in converting and controlling the flow of electrical energy. Simply charging a laptop, for example, requires modifying the alternating-current (AC) voltage from the electricity mains to a lower voltage direct current (DC) and if that current originally came from a solar panel, it will have already been converted from DC voltage to the (European) standard 230 volts, 50 hertz AC voltage, using a power electronics-based converter called a solar inverter.

The systems and machines of our world depend on power electronics for the ability to run efficiently and sustainably. Power electronics is the application of solid-state electronics for the control and conversion of electric power. It applies to both the systems and products involved in converting and controlling the flow of electrical energy, allowing the electricity needed for everyday products to be delivered with maximum efficiency in the smallest and lightest package.
Two controlling techniques are available. These are,

1. Voltage controlling
2. Current controlling

Though, voltage controlling can control the voltage efficiently we prefer to use current controlling technique as current is major consideration in our project. Current can be sensed by using series resistor. But loss of current is in the form of heat. There is wastage of power and it will give inaccurate values. To overcome the disadvantage of this EMI based sensing is used. A Hall Effect sensor is a transducer that varies its output voltage in response to a magnetic field. Hall Effect sensors are used for proximity switching, positioning, speed detection, and current sensing applications.

In a Hall Effect sensor a thin strip of metal has a current applied along it, in the presence of a magnetic field the electrons are deflected towards one edge of the metal strip, producing a voltage gradient across the short-side of the strip (perpendicular to the feed current). Inductive sensors are just a coil of wire, in

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the presence of a changing magnetic field a current will be induced in the coil, producing a voltage at its output. Hall Effect sensors have the advantage that they can detect static (non-changing) magnetic fields toHall Effect sensor gives an accurate result. Current consumption is also same if we use more resistive loads.

2. Block Diagram

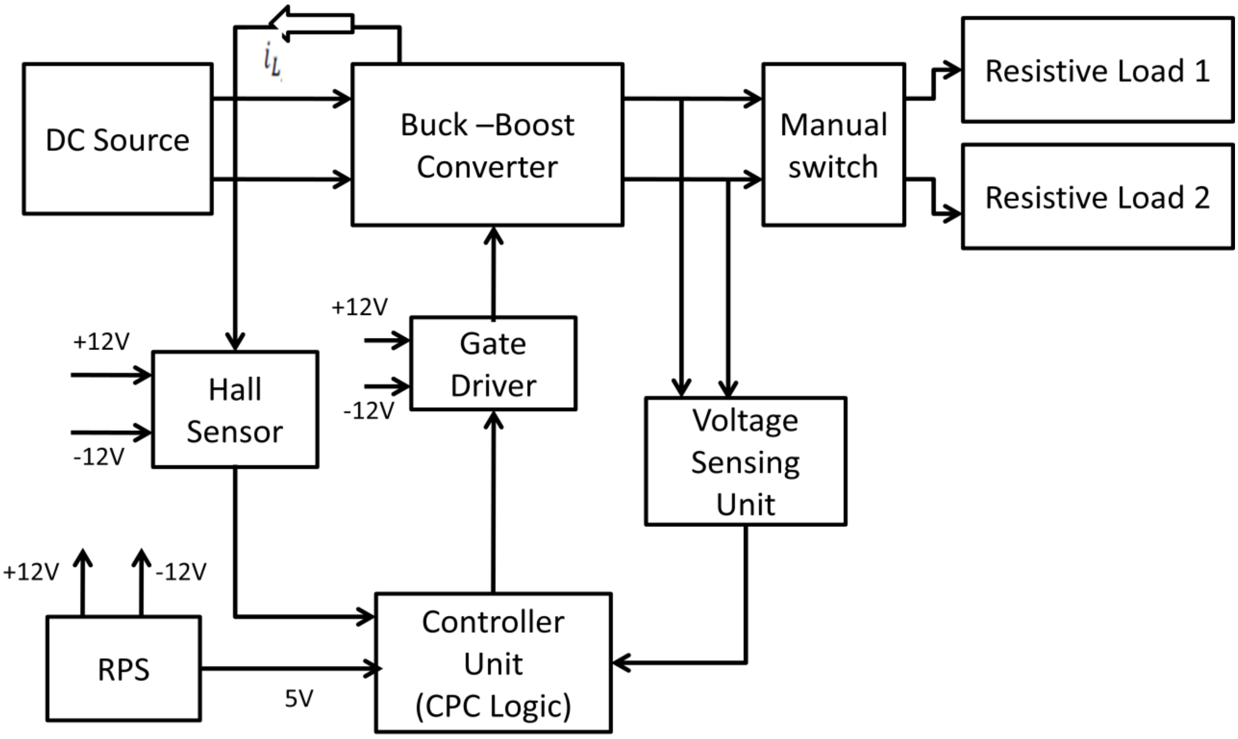

Figure 2. Block diagram.

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3. Circuit Diagram

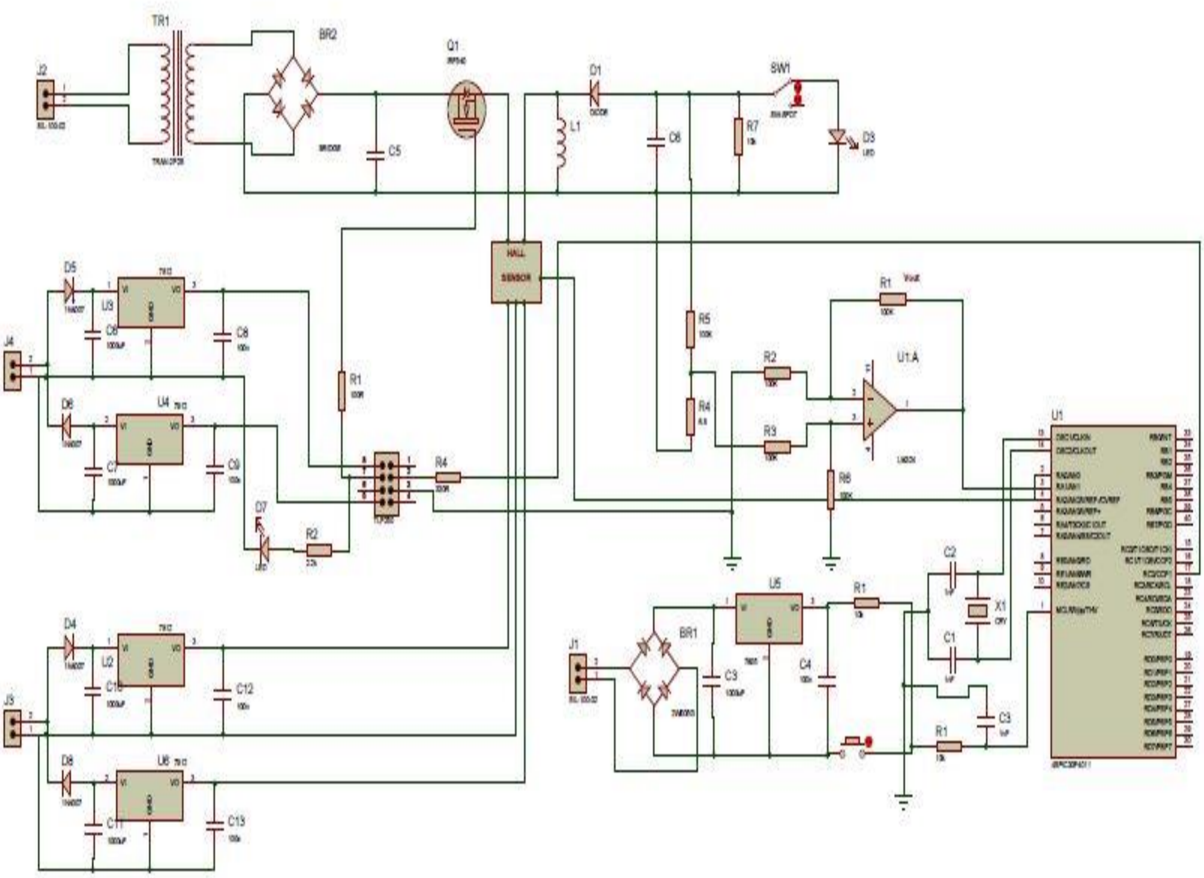

Figure 3. Circuit Diagram.

The input voltage was taken from 230V supply and stepped down to 12V.The output of the transformer was converted to DC voltage source using bridge rectifier and Capacitive filter.The DC output voltage was feed to the Buck Boost converter, In that converter used the IRF540 MOSFET switches.The output of the converter is connected to the R-Load and additional load LED was connected using the LED load.The output voltage was sensed by the voltage sensing unit. In the unit we used the LM324 IC.The inductor current also sensed by the HALL Sensor.The dSPIC18F4011 was used to control the overall system. This controller needs the 5V constant voltage source using 7805 Regulator.The sensor outputs are connected Analog ports of the controller.The controller output pulses are pass to the GATE Driver unit. At the same time the Dual RPS was provides supply to the GATE Driver unit.The GATE DRIVER (TLP250) was stepped up the pulse amplitude.The HALL sensor needs the 12V supply it could be taken from another dual RPS

SOFTWARE :

4.1 CCS Software

A compiler is a computer program (or set of programs) that transforms source code written in a programming language (the source language) into another computer language (the target language, often having a binary form known as object code). The most common reason for wanting to transform source code is to create an executable program.This integrated C development environment gives developers the capability to quickly produce very efficient code from an easily maintainable high level language. The compiler includes built-in functions to access the PIC microcontroller hardware such as READ_ADC to read a value from the A/D converter. Discrete I/O is handled by describing the port characteristics in a PROGRAM. Functions such as INPUT and OUTPUT_HIGH will properly maintain the tri-state registers. Variables including structures may be directly mapped to memory such as I/O ports to best represent the hardware structure in C.

4.2 Embedded C

Looking around, we find ourselves to be surrounded by various types of embedded systems. Be it a digital camera or a mobile phone or a washing machine, all of them has some kind of processor functioning inside it. Associated with each processor is the embedded software. If hardware forms the body of an embedded system, embedded processor acts as the brain, and embedded software forms its soul. It is the embedded software which primarily governs the functioning of embedded systems.During infancy years of microprocessor based systems, programs were developed using assemblers and fused into the EPROM's. There used to be no mechanism to find what the program was doing. LEDs, switches, etc.

4.3MATLAB

The MATLAB language provides native support for the vector and matrix operations that are fundamental to solving engineering and scientific problems, enabling fast development and execution. MATLAB provides features of traditional programming languages, including flow control, error handling, and object-oriented programming (OOP). You can use fundamental data types or advanced data structures, or you can define custom data types. MATLAB add-on products provide built-in algorithms for signal processing and communications, image and video processing, control systems, and many other domains. By combining these algorithms with your own, you can build complex programs and applications.

HARDWARE:

5.1 DSPIC30F4011

5.1.1 High Performance Modified Risc CPU

- Modified Harvard architecture
- C compiler optimized instruction set architecture with flexible addressing modes
- 84 base instructions
- 24-bit wide instructions, 16-bit wide data path
- 48 Kbytes on-chip Flash program space (16K Instruction words)
- 2 Kbytes of on-chip data RAM

- 1 Kbytes of non-volatile data EEPROM
- Up to 30 MIPs operation:
  - DC to 40 MHz external clock input
  - 4 MHz-10 MHz oscillator input with PLL active (4x, 8x, 16x)
- 30 interrupt sources
  - 3 external interrupt sources
  - 8 user selectable priority levels for each interrupt source
  - 4 processor trap sources
- 16 x 16-bit working register array

5.1.4 Motor Control PWM Module Features

- 6 PWM output channels
  - Complementary or Independent Output modes
  - Edge and Center Aligned modes
- 3 duty cycle generators
- Dedicated time base
- Programmable output polarity
- Dead-time control for Complementary mode
- Manual output control
- Trigger for A/D conversions

5.1.5 Quadrature Encoder Interface Module Features

- Phase A, Phase B and Index Pulse input
- 16-bit up/down position counter
- Count direction status
- Position Measurement (x2 and x4) mode
- Programmable digital noise filters on inputs
- Alternate 16-bit Timer/Counter mode
- Interrupt on position counter rollover/underflow

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5.1.8 Pin Diagram

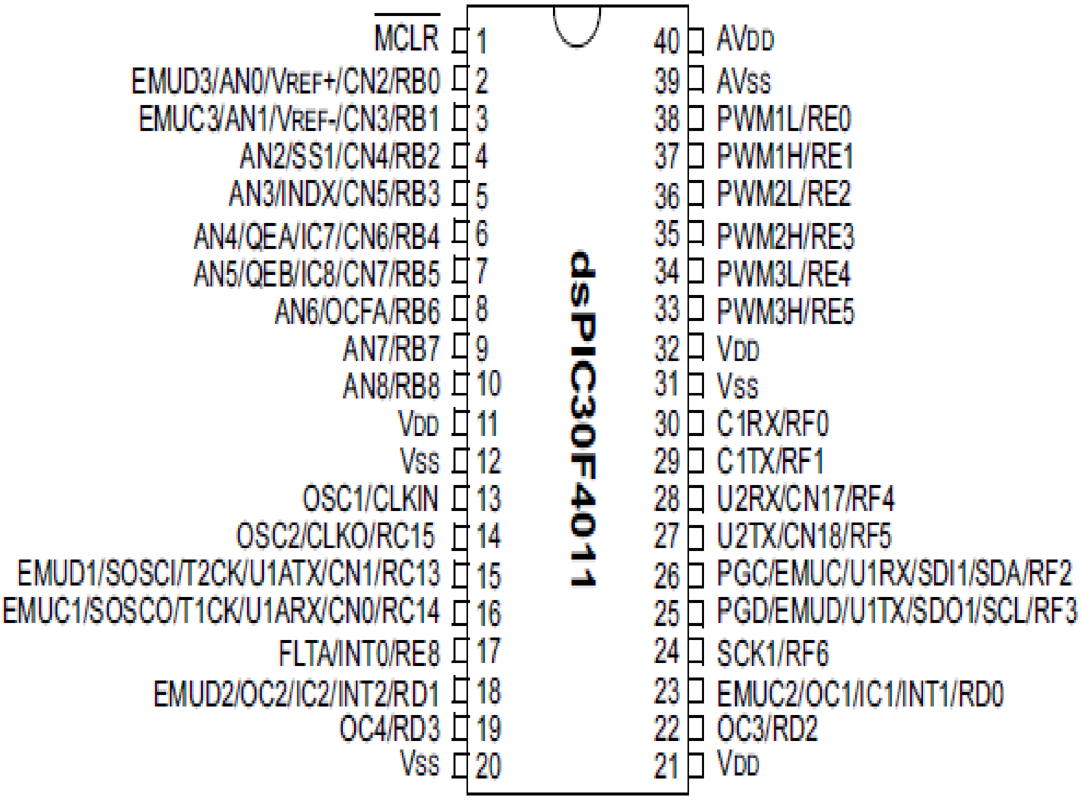

Figure 5.1Pin Diagram.

5.4 Voltage Sensor

To obtain DC signal from an AC system for the input to a microcontroller, we are using this Voltage sensing circuit. The circuit provides an accurate method for creating this DC signal.The voltage is sensed by using a Potential Transformer and the obtained signal is rectified at the first op-amp stage and amplifier at the second op-amp stage.

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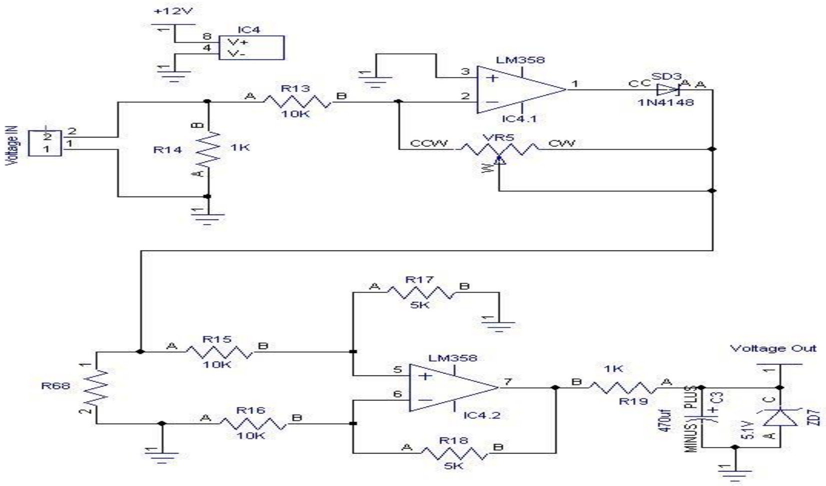

Figure 5.3 Voltage Sensor

5.5 Hall Effect Current Sensors

The Hall Effect comes about due to the nature of the current in a conductor. Current consists of the movement of many small charge carriers, typically electrons, holes, ions (see Electromigration) or all three. When a magnetic field is present that is not parallel to the direction of motion of moving charges, these charges experience a force, called the Lorentz force. When such a magnetic field is absent, the charges follow approximately straight, 'line of sight' paths between collisions with impurities, phonons, etc. However, when a magnetic field with a perpendicular component is applied, their paths between collisions are curved so that moving charges accumulate on one face of the material. This leaves equal and opposite charges exposed on the other face, where there is a scarcity of mobile charges. The result is an asymmetric distribution of charge density across the Hall element that is perpendicular to both the 'line of sight' path and the applied magnetic field. The separation of charge establishes an electric field that opposes the migration of further charge, so a steady electricalpotential builds up for as long as the charge is flowing.

It should be noted that in theclassical view, there are only electrons moving in the same average direction both in the case of electron or Hole conductivity. This cannot explain the opposite sign of the Hall Effect observed. The difference is that electrons in the upper bound of the valence band have opposite group velocity and wave vector direction when moving, which can be effectively treated as if positively charged particles (holes) moved in the opposite direction to that of the electrons.

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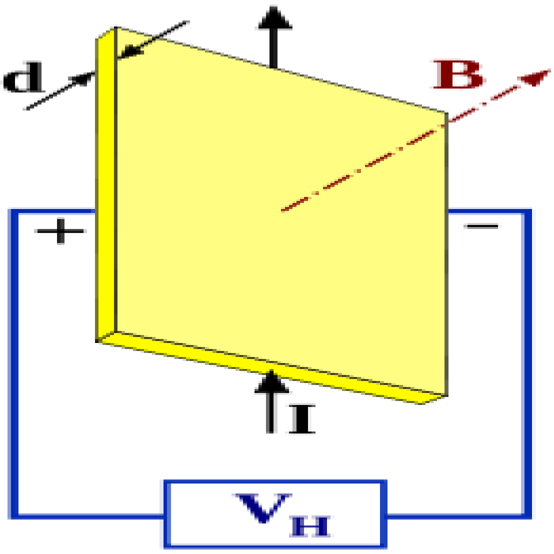

Figure 5.4 Hall Effect Current Sensors

For a simple metal where there is only one type of charge carrier (electrons) the Hall voltage $V_H$is given by

$$V_H = \frac{-IB}{ned}$$

WhereIis the current across the plate length, (thickness) of the plate, e is the electron density of the carrier electrons.

B is the magnetic field, d is the depth charge, and n is the charge carrier

The Hall coefficient is defined as

$$R_H = \frac{E_y}{j_x B}$$

Wherej is the current density of the carrier electrons, and E_y is the induced electric field. In SI units, this becomes

$$R_H = \frac{E_y}{j_x B} = \frac{V_H d}{IB} = -\frac{1}{ne}$$

As a result, the Hall Effect is very useful as a means to measure either the carrier density or the magnetic field.

One very important feature of the Hall Effect is that it differentiates between positive charges moving in one direction and negative charges moving in the opposite. The Hall Effect offered the first real proof that electric currents in metals are carried by moving electrons, not by protons. The Hall effect also showed that in some substances (especially p-type semiconductors), it is more appropriate to think of the current as positive "holes" moving rather than negative electrons. A common source of confusion with the Hall Effect is that holes moving to the left are really electrons moving to the right, so one expects the same sign of the Hall coefficient for both electrons and holes. This confusion, however, can only be resolved by modern quantum mechanical theory of transport in solids.It must be noted though that the sample inhomogeneity might result in spurious sign of the Hall Effect, even in ideal Vander Pawconfigure ration of electrodes. For example, positive Hall Effect was observed in evidently n-type semiconductors.

5.6 Gate Driver

- Gate driver is a power amplifier that accepts a low power input from a controller IC and produces the appropriate high current gate drive for a power MOSFET.
- They can also be integrated within a controller
- The main purpose of gate driver circuit is

1. Isolation purpose

2. Efficient driving (PUSH-PULL amplifier)

3.PWM protector

5.6.1 TLP 250
Schematic Diagram

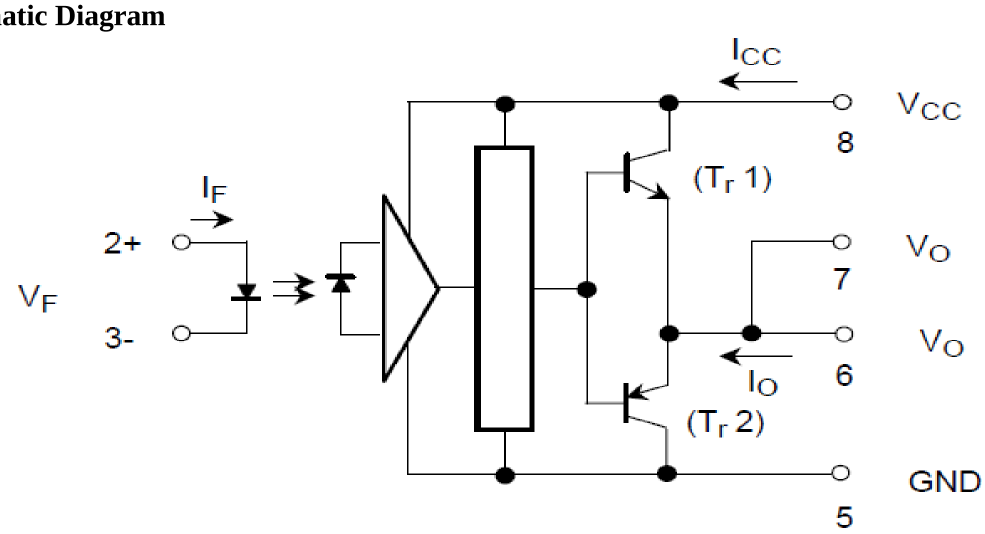

Figure 5.5 TLP 250

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5.6.2 TLP 250 IC Pin Diagram

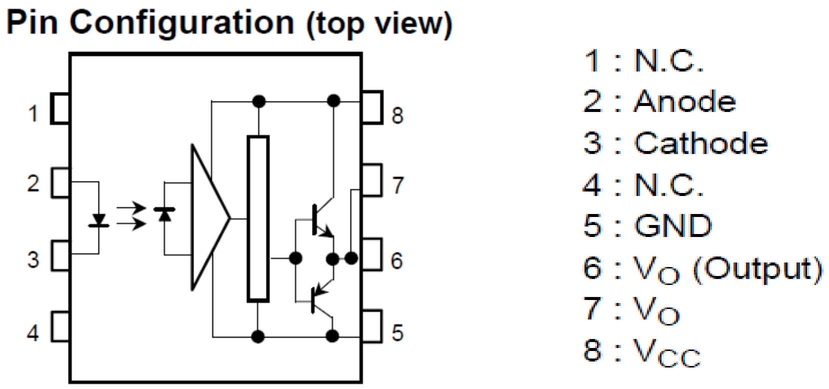

Figure 5.6 IC Pin

5.7 Regulated Power Supply

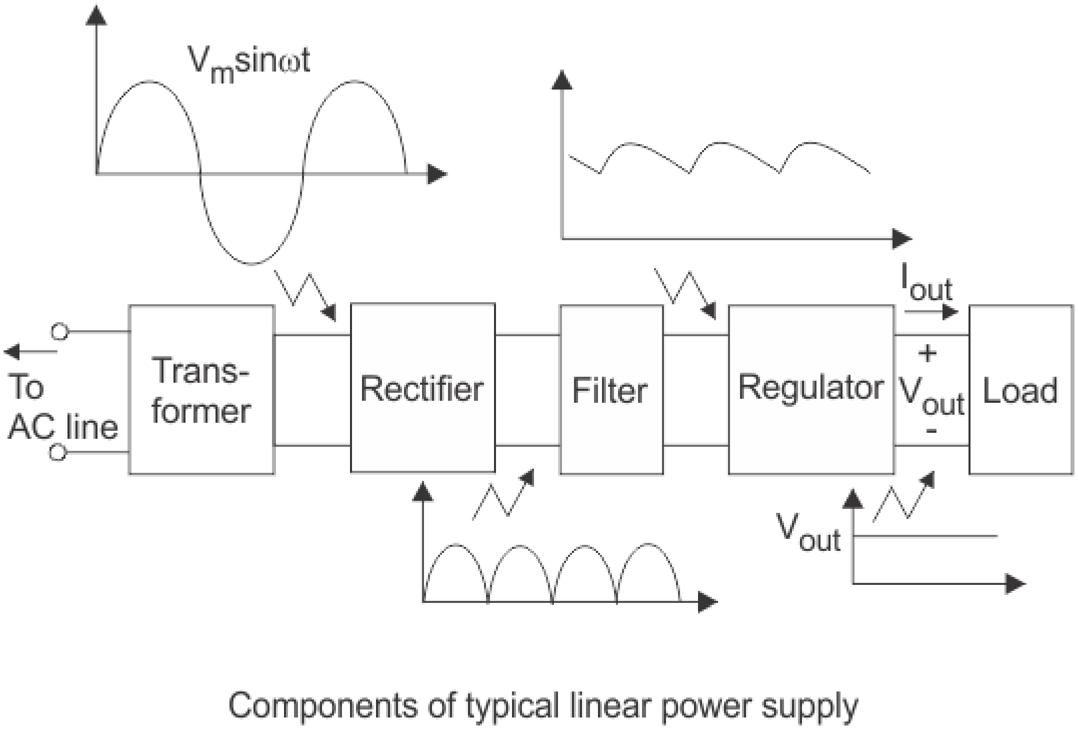

Figure 5.8 Regulated power supply

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6.1 Simulation Diagram

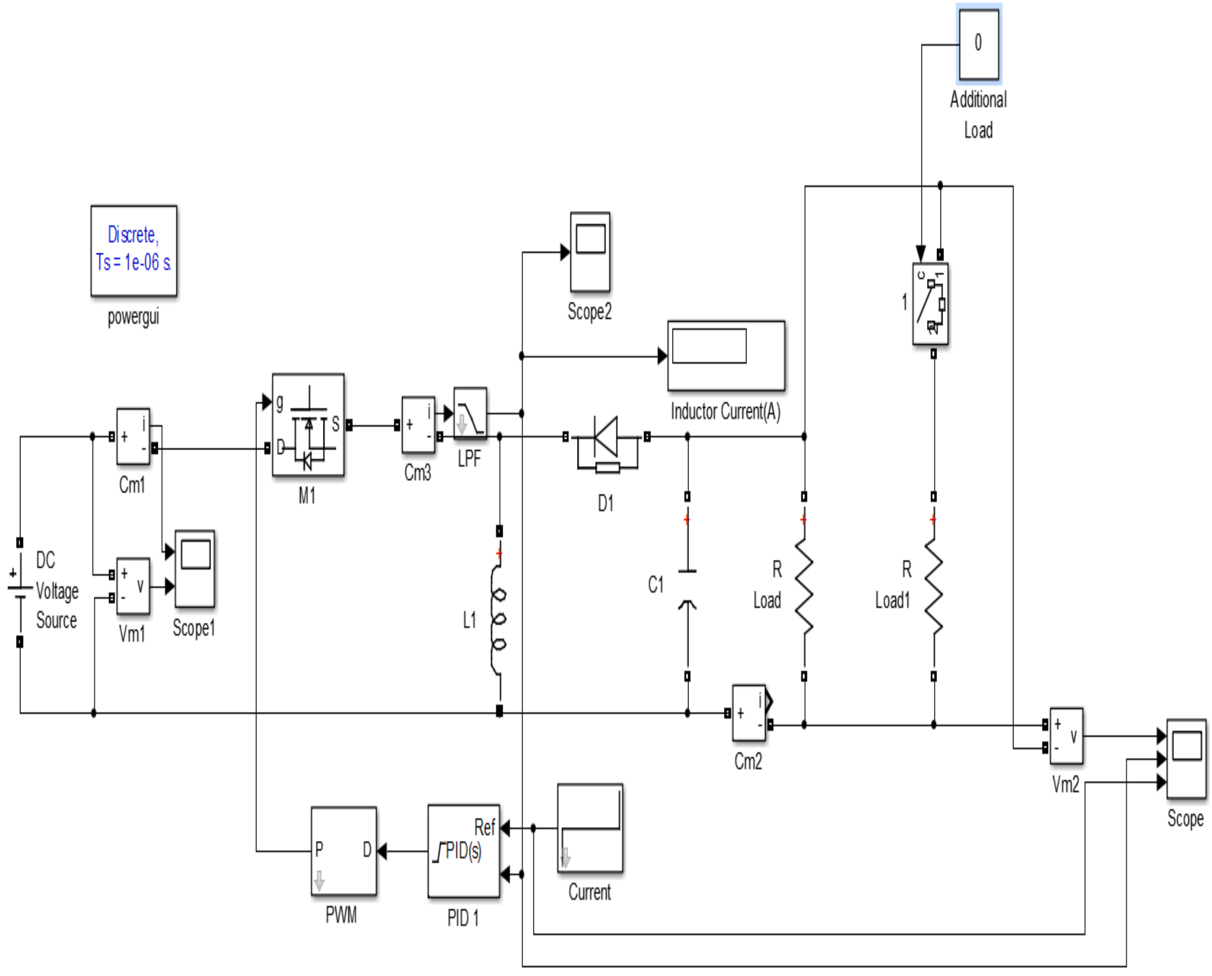

Figure 6.1 Simulation Diagram

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6.2 Simulation Input

Voltage and Current

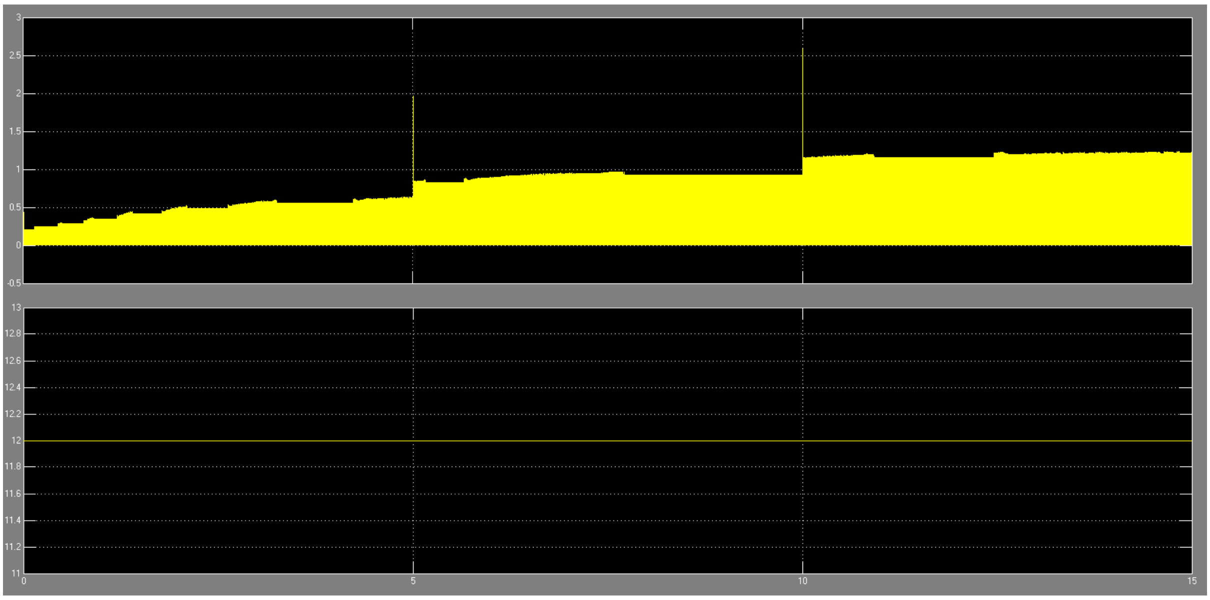

Figure 6.2 Simulation Input

6.3 Simulation Output

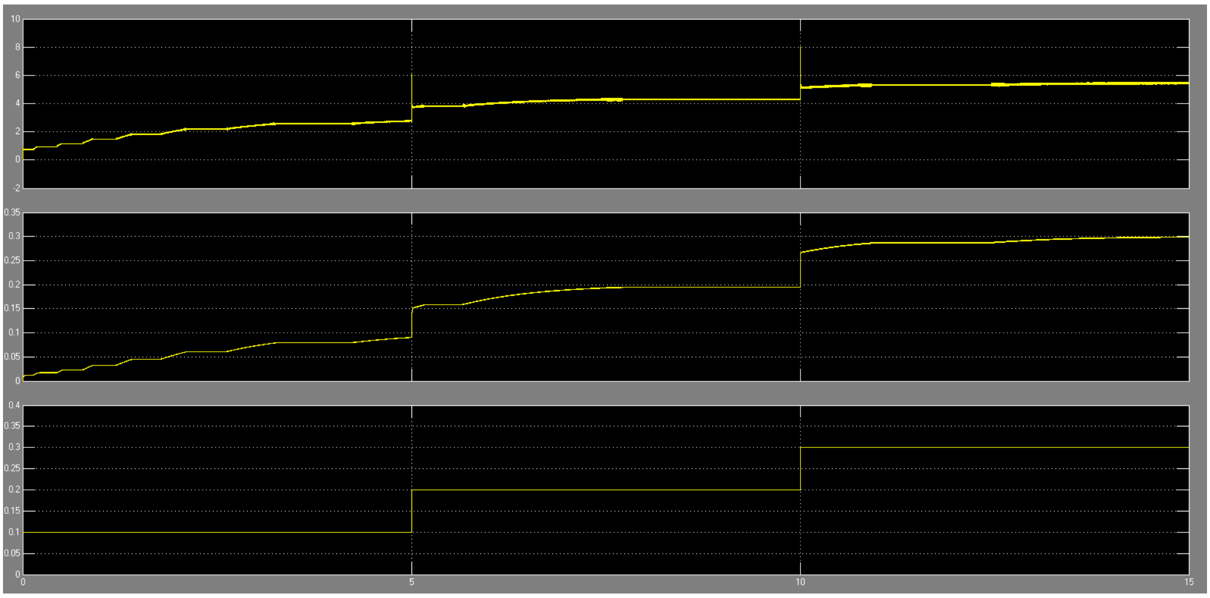

Figure6.3 Simulation Output

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7.1 Hardware Output

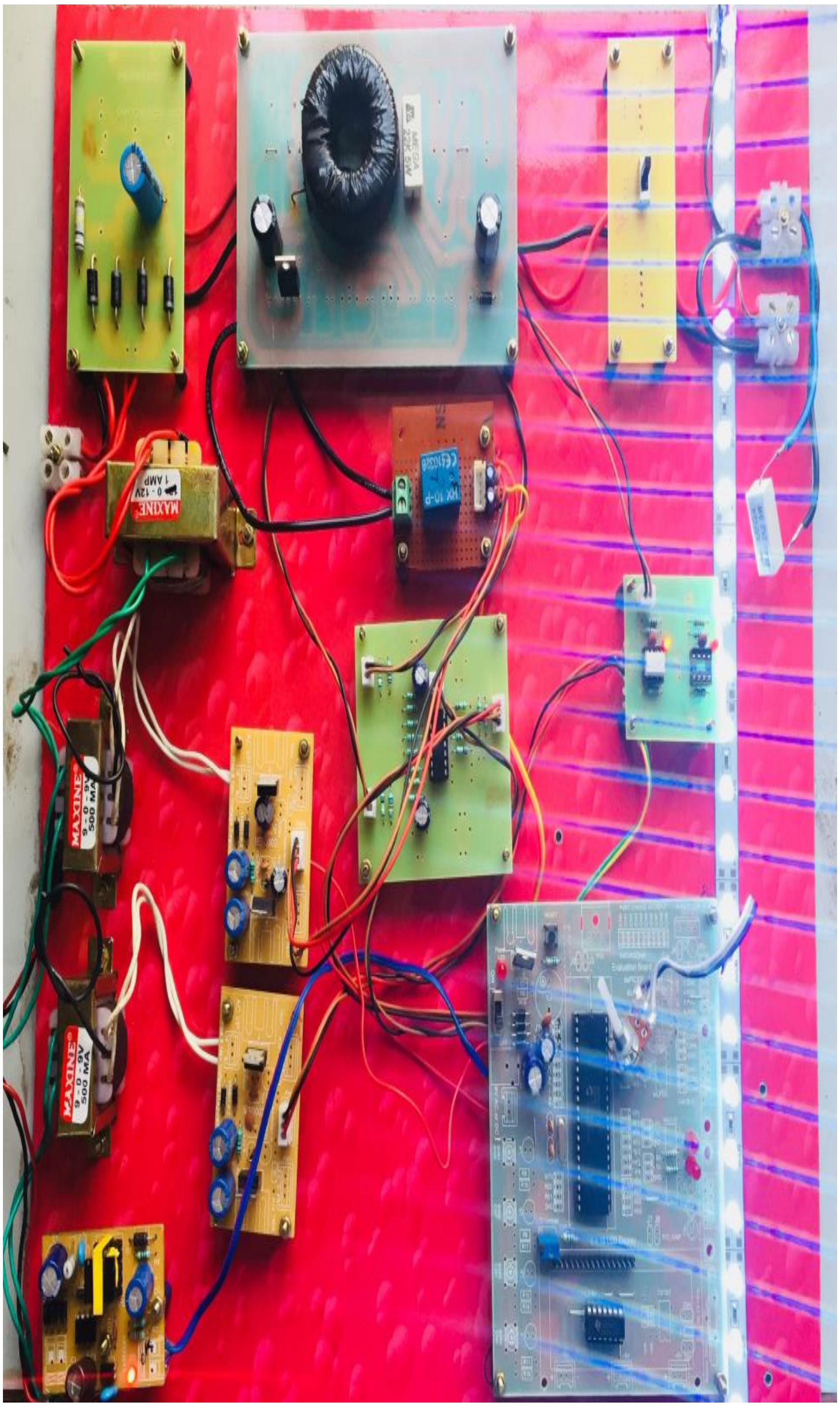

Figure 7.1 Hardware output

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7.2 Hell effect sensor

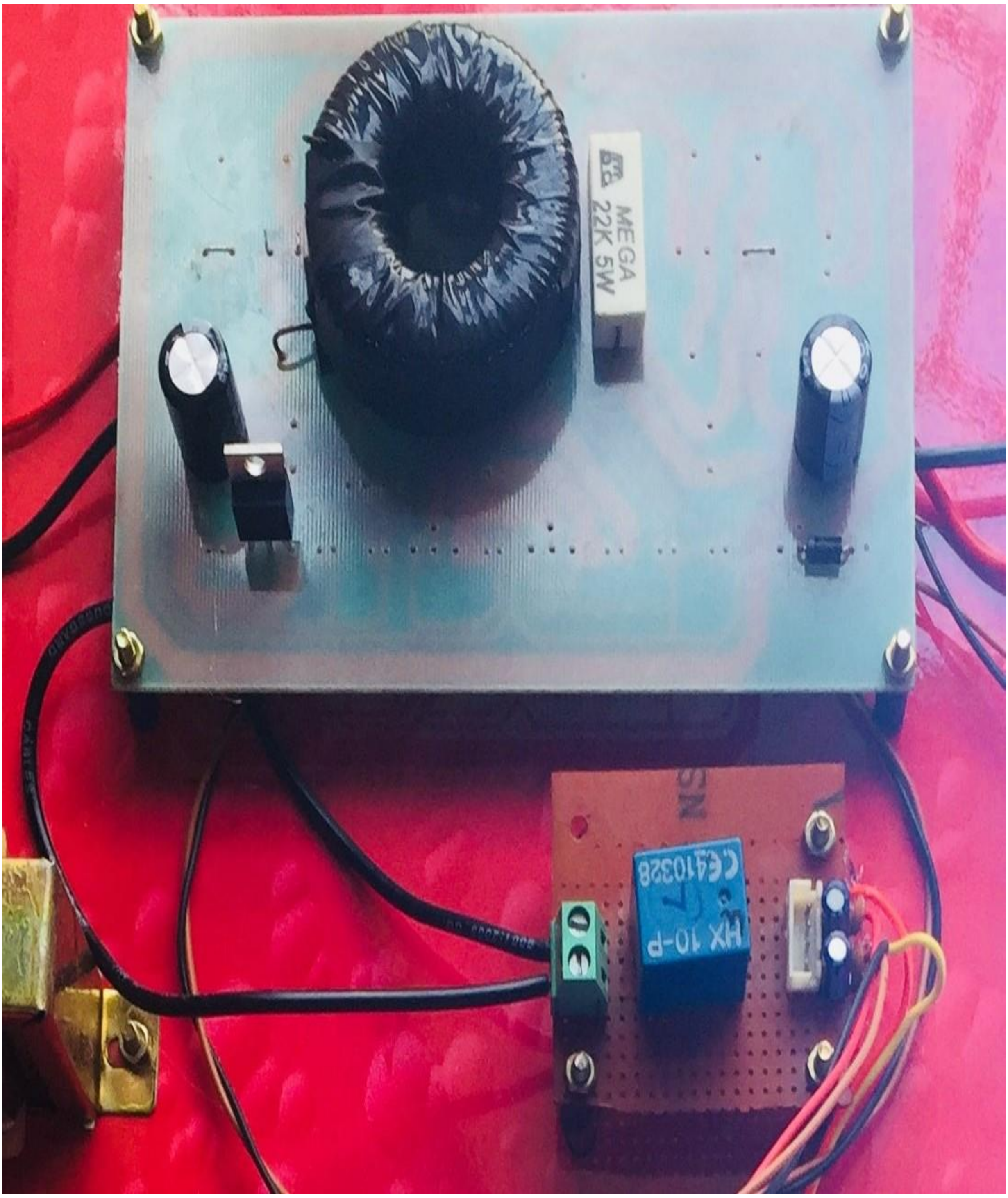

Figure 7.2 Hell effect sensor

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Conclusion

This proposed system can be used in variety of applications such as battery charging, LED's and electrophoresis. Electrophoresis is the motion of dispersedparticles relative to a fluid under the influence of a spatially uniform electric field. This system can use the current in an efficient way. Further enhancement can be made to detect the lifetime of loads. This proposed model utilizes current sensing to get the output in an appropriate manner. As it consumes same current for one or more loads it helps in industrial way. Also it is cost effective since it uses simple components to construct the circuit. In this way, this system would be minimizing the requirement of power and thus providing efficiency and accuracy in the power system.

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