BUCK-BOOST POWER LED DRIVER USING PIC MICROCONTROLLER

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Signature : ________________________________
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Date : 17 NOVEMBER 2008
To my beloved mother, father, sister, brother and my love
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ABSTRACT

One traditional low-cost way of driving LED in electrical applications uses a resistor in series with the LED device. Although this driving scheme is simple and inexpensive, it suffers several disadvantages. The LED current can vary substantially over the battery voltage range even in normal operation of the device, thus affecting the brightness and reducing the service life of the lighting device. Additionally, protection is needed from automotive voltage transients and reverse polarity. These disadvantages are typically resolved by using constant-current linear regulators. Besides driving the LED at a programmed current, these regulators can inherently protect from a reverse-polarity application and block voltage transients up to tens of volts. Linear current regulators do not require input EMI filters and can yield inexpensive LED driver solutions. However, both the resistor ballasts and the linear regulators exhibit low efficiency. They may become impractical for driving high-brightness LED loads due to the excessive heat dissipation. Therefore, switching power converters are needed for driving many signal and lighting LED devices.
ABSTRAK

Pada masa dahulu, cara lama untuk menghidupkan lampu LED dalam semua aplikasi adalah dengan menggunakan perintang yang diletakkan dalam keadaan bersiri dengan lampu LED. Walaupun cara ini nampak mudah dan tidak menggunakan kos yang banyak tapi sebenarnya terdapat banyak kelemahan dalam menggunakan cara ini. Semasa menggunakan cara yang lama ini, arus elektrik yang digunakan untuk menghidupkan lampu ini akan berubah mengikut had lingkungan operasi voltan bateri itu dan ini akan menyebabkan keterangan lampu akan berkurang dan jangka hayat lampu juga sama. Namun begitu, masalah ini boleh diatasi dengan menggunakan arus terus regulator dan dengan menggunakan alat ini, masalah seperti perubahan voltan dapat diatasi. Arus terus regulator juga tidak memerlukan input penapis EMI dan juga ia sangat murah untuk digunakan. Namun begitu, dengan regulator ini keberkesanan kuasa yang masuk ke dalam lampu akan berkurang juga dan ini tidak sesuai untuk menjanakn lampu LED yang berkuasa tinggi jadi dengan menggunakan sistem yang direka inilah semua masalah itu akan diatasi.
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<td>LED</td>
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<td>LCD</td>
<td>Liquid Crystal Display</td>
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<td>ROM</td>
<td>Read Only Memory</td>
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<tr>
<td>EPROM</td>
<td>Erasable Read Only Memory</td>
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<td>RAM</td>
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<td>OSC</td>
<td>Oscillator</td>
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<td>SMPS</td>
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<td>PWM</td>
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<td>ADC</td>
<td>Analog digital converter</td>
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<td>-</td>
<td>Micro</td>
</tr>
<tr>
<td>K</td>
<td>-</td>
<td>Kilo</td>
</tr>
<tr>
<td>m</td>
<td>-</td>
<td>mili</td>
</tr>
<tr>
<td>kHZ</td>
<td>-</td>
<td>Kilohertz</td>
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<tr>
<td>V</td>
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<tr>
<td>I</td>
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CHAPTER 1

INTRODUCTION

1.1 Overview of Project

In this project, I will be designing a power LED driver using PIC microcontroller and also buck-boost converter. The reason for me to design such a driver is to provide an efficient solution to the old method using a resistor in series to limit the current through the power LED because by using the method the LED will result not having enough efficiency at the typical power levels required for it to operate. But by using the LED driver, the input voltage can be adjusted to the correct level of voltage and supply the desired current for LED and also with this driver it will provide a more efficient solution for driving a high power LED and increase the efficiency of the power levels required for the LED to operate.

Typically boost converter are used in many electrical application for driving long strings of LED such as in instrument panel backlights and other lighting devices that require series connection of multiple LED. A typical boost converter can drive strings of LED having forward voltage in excess of 100 V. However, recent advances in the high-brightness LED technology have substantially increased the power ratings of a single LED package. LED current of 350mA,700mA or even 1A are typical. Therefore, the number of series-connected LED in the string used in any lighting devices has become smaller. Despite its simplicity, the boost converter of suffers a serious drawback in many of the electrical application systems where the supply line voltage can easily exceed the forward voltage of the LED string.

Boost-buck converters can offer a solution for most of the higher-power lighting applications, including both exterior and interior lighting. It can fit well even in forward-lighting devices, when they become available.
A CCM buck-boost converter integrates an input boost stage and an output buck stage, thus being able to step the input voltage up or down as needed. Both the input and the output currents of the converter are continuous, yielding good EMI performance.

1.2 Scope of Project and Objective

In this project, there are three scopes that were proposed. One of it is to design and fabricate controller circuit using PIC microcontroller. The PIC microcontroller that I will be using is PIC16F785 because it has many suitable characteristic for it to be the Power LED driver. The second one is to design and fabricate Buck-Boost converter. Even thought that Buck-Boost converter circuit are fixed it still need to redesign again into more suitable circuit that is convenient to this application. The third one is to control Buck-Boost converter the PIC microcontroller.

The objective of this project is to design a system that provides more efficient solution for driving a high power LED by controlling the LED forward current using Buck-Boost converter. It is because the system that already has in lightning the power LED has a lot of power loss and decrease it efficiency and by using this designed driver, all the problems occurred in the previous mill be solved.

1.2 Efficient LED Control

LED’s must be driven with a source of constant current. Most of LED’s have a specified current level that will achieve the maximum brightness for that LED’s without premature failure. LED could be driven with a linear voltage regulator configured as a constant current source. However, this approach is not practical for higher power LED’s due to power dissipation in the regulator circuit. A switch mode power supply (SMPS) provides a much more efficient solution to drive the LED.
An LED will have a forward voltage drop across it terminal for a given current drive level. The power supply voltage and the LED forward voltage characteristic will determine the SMPS topology that is required.

The SMPS circuit topologies adopted to regulated current in LED lighting application are the same used to control voltage in a power supply application. Each type of SMPS topology has its own advantage and disadvantage and boost-buck can offer a solution for most of the higher-power lighting applications, including both exterior and interior lighting.

1.3 **Trend of Power Electronic Switch**

The key components of the proposed DC-DC converter are the power semiconductor switches. As the main advantage of the proposed DC-DC converter is to reduce power loss and increase the system efficiency using the appropriate power electronic power switch. So, it is worth to give some introduction to the trend of the modern power semiconductor device applicable to DC-DC converter mainly are IGBT, GTO and MOSFET.

IGBT’s of 3.3 KV 1200A are now commercially available in the market and GTO’s with the rating of 60 KV and 4500A have been commercially available for several years. The higher voltage and current rating of GTO’s can be manufactured with the existing manufacturing technology if required by market. GTO has the advantage of very low on-state conduction losses compared with other available power semiconductor device. However it has the advantage of being slow and required a complicated turn off circuit.

As a majority carrier device, power MOSFET has a very high switching speed. However since the conductivity modulation, a phenomenon of a minority carrier device such as BJT and GTO does not exist in power MOSFET, the on state conduction losses of this device are too high for application that required high voltage and high power.
The main advantage of MOSFETs for digital switching is that the oxide layer between the gate and the channel prevents DC current from flowing through the gate, further reducing power consumption and giving very large input impedance. This is the reason of choosing MOSFET in our application.
CHAPTER 2

Literature Review

2.1 Dc–dc converter

2.1.1 Definition

Dc-dc converters are power electronic circuits that convert a dc voltage to a different dc voltage level, often providing a regulated output. The circuits described are classified as switched mode dc-dc converter and also called switching power supplies or switcher. There are also some common variation of the dc-dc converter circuits that are used in many dc power supply design [2].

Dc-dc converters are important in portable electronic devices such as cellular phones and laptop computers, which are supplied with power from batteries. Such electronic devices often contain several sub-circuits with each sub-circuit requiring a unique voltage level different than that supplied by the battery. Additionally, the battery voltage declines as its stored power is drained. Dc-dc converters offer a method of generating multiple controlled voltages from a single variable battery voltage, thereby saving space instead of using multiple batteries to supply different parts of the device [4].

2.1.2 Switching Regulator

A switching regulator is a circuit that uses a power switch, an inductor, and a diode to transfer energy from input to output. The basic components of the switching circuit can be rearranged to form a step-down (buck), step-up (boost), or an inverter
(flyback). These designs are shown in figures 2.1, 2.2, 2.3, and 2.4 respectively, where figures 2.3 and 2.4 are the same except for the transformer and the diode polarity. Feedback and control circuitry can be carefully nested around these circuits to regulate the energy transfer and maintain a constant output within normal operating conditions [3].

Switching regulators offer three main advantages compared to a linear regulators. First, switching efficiency can be much better than linear. Second, because less energy is lost in the transfer, smaller components and less thermal management are required. Third, the energy stored by an inductor in a switching regulator can be transformed to output voltages that can be greater than the input (boost), negative (inverter), or can even be transferred through a transformer to provide electrical isolation with respect to the input.

Given the advantages of switching regulators, one might wonder where linear regulators can be used. Linear regulators provide lower noise and higher bandwidth; their simplicity can sometimes offer a less expensive solution.
There are, admittedly, disadvantages with switching regulators. They can be noisy and require energy management in the form of a control loop. Fortunately the solution to these control problems is found integrated in modern switching-mode controller chips.

2.1.3 Switched-mode conversion

Electronic switch-mode DC to DC converters convert one DC voltage level to another, by storing the input energy temporarily and then releasing that energy to the output at a different voltage. The storage may be in either magnetic components (inductors, transformers) or capacitors. This conversion method is more power efficient (often 75% to 98%) than linear voltage regulation (which dissipates unwanted power as heat). This efficiency is beneficial to increasing the running time of battery operated devices. The efficiency has increased in since the late 1980's due to the use of power FETs, which are able to switch at high frequency more efficiently than power bipolar transistors, which have more switching losses and require a more complex drive circuit. Another important innovation in DC-DC converters is the use of synchronous switching which replaces the flywheel diode with a power FET with low "On" resistance, thereby reducing switching losses [4].

Drawbacks of switching converters include complexity, electronic noise (EMI / RFI) and to some extent cost, although this has come down with advances in chip design [2]. DC to DC converters are now available as integrated circuits needing minimal additional components. DC to DC converters are also available as a complete hybrid circuit component, ready for use within an electronic assembly.
2.1.4 Buck Converter

A buck converter is a step-down DC to DC converter. Its design is similar to the step-up boost converter, and like the boost converter it is a switched-mode power supply that uses two switches (a transistor and a diode) and an inductor and a capacitor. The simplest way to reduce a DC voltage is to use a voltage divider circuit, but voltage dividers waste energy, since they operate by bleeding off excess voltage as heat; also, output voltage isn't regulated (varies with input voltage). A buck converter, on the other hand, can be remarkably efficient (easily up to 95% for integrated circuits) and self-regulating, making it useful for tasks such as converting the 12-24V typical battery voltage in a laptop down to the few volts needed by the processor [4].

2.1.4.1 Principle of operation

In this circuit the transistor turning ON will put voltage Vin on one end of the inductor. This voltage will tend to cause the inductor current to rise. When the transistor is OFF, the current will continue flowing through the inductor but now flowing through the diode. We initially assume that the current through the inductor does not reach zero, thus the voltage at Vx will now be only the voltage across the conducting diode during the full OFF time. The average voltage at Vx will depend on the average ON time of the transistor provided the inductor current is continuous [4].

![Figure 2.5: Buck Converter](image)
To analyze the voltages of this circuit let us consider the changes in the inductor current over one cycle. From the relation

\[ V_x - V_0 = L \frac{di}{dt} \]  \hspace{1cm} (Equation 2.0)

the change of current satisfies

\[ di = \int_{ON} (V_x - V_0) dt + \int_{OFF} (V_x' - V_0') dt \] \hspace{1cm} (Equation 2.1)

For steady state operation the current at the start and end of a period T will not change. To get a simple relation between voltages we assume no voltage drop across transistor or diode while ON and a perfect switch change. Thus during the ON time \( V_x = V_{in} \) and in the OFF \( V_x = 0 \). Thus

\[ 0 = di = \int_{ON} (V_{in} - V_0) dt + \int_{OFF} V_{in} dt \] \hspace{1cm} (Equation 2.2)

which simplifies to

\[ (V_{in} - V_0) t_{on} - V_0 t_{off} = 0 \] \hspace{1cm} (Equation 2.3)

or

\[ \frac{V_0}{V_{in}} = \frac{t_{on}}{T} \] \hspace{1cm} (Equation 2.4)

Figure 2.6: Voltage and current changes
and defining "duty ratio" as

\[ D = \frac{I_{on}}{T} \]  

(Equation 2.5)

the voltage relationship becomes \( V_o = D V_{in} \). Since the circuit is lossless and the input and output powers must match on the average \( V_o \times I_o = V_{in} \times I_{in} \). Thus the average input and output current must satisfy \( I_{in} = D I_o \). These relations are based on the assumption that the inductor current does not reach zero [4].

### 2.1.5 Boost converter

A boost converter (step-up converter) is a power converter with an output DC voltage greater than its input DC voltage. It is a class of switching-mode power supply (SMPS) containing at least two semiconductor switches (a diode and a transistor) and at least one energy storage element. Filters made of capacitors (sometimes in combination with inductors) are normally added to the output of the converter to reduce output voltage ripple [2].

An AC mains voltage cannot directly power devices such as computers, digital clocks, and telephones. The outlet supplies AC and the devices and loads require DC. Power conversion enables DC devices to utilize power from ac voltage sources. A process called ac to dc conversion (rectification) is used to convert an AC voltage to power a DC load.

Power can also come from DC sources such as batteries, solar panels, rectifiers, and DC generators. A process that changes one DC voltage to a different DC voltage is called dc to dc conversion. A boost converter is a DC to DC converter with an output voltage greater than the source voltage. A boost converter is sometimes called a step-up converter since it “steps up” the source voltage. Since power \((V*I)\) must be conserved, the output current is lower than the source current.
2.1.5.1 Principle of operation

The schematic in figure 2.7 shows the basic boost converter. This circuit is used when a higher output voltage than input is required.

![Boost Converter Circuit](image)

Figure 2.7: Boost Converter Circuit

While the transistor is ON $V_x = V_{in}$, and the OFF state the inductor current flows through the diode giving $V_x = V_o$. For this analysis it is assumed that the inductor current always remains flowing (continuous conduction). The voltage across the inductor is shown in figure 2.8 and the average must be zero for the average current to remain in steady state

$$V_{in} \cdot t_{on} + (V_{in} - V_o) \cdot t_{off} = 0$$  \hspace{1cm} \text{(Equation 2.6)}

This can be rearranged as

$$\frac{V_o}{V_{in}} - \frac{T}{t_{off}} = \frac{1}{(1 - D)}$$  \hspace{1cm} \text{(Equation 2.7)}

and for a lossless circuit the power balance ensures

$$\frac{I_o}{I_{in}} = (1 - D)$$  \hspace{1cm} \text{(Equation 2.8)}
Since the duty ratio "D" is between 0 and 1 the output voltage must always be higher than the input voltage in magnitude. The negative sign indicates a reversal of sense of the output voltage [4].

2.1.6 Buck-Boost Converter

The buck-boost converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude. It is a switch mode power supply with a similar circuit topology to the boost converter and the buck converter. The output voltage is adjustable based on the duty cycle of the switching transistor. One possible drawback of this converter is that the switch does not have a terminal at ground, this complicates the driving circuitry. The polarity of the output voltage is opposite the input voltage so neither drawback is of any consequence if the power source is isolated from the load circuit (if, for example, the source is a battery) as the source and diode can simply be reversed and the switch moved to the ground side.
The circuit topology of buck-boost converter is similar with the buck converter and also buck converter, the different between this three converters are only the position of their inductor, diode and the switch [2]. The output voltage is adjustable based on the duty cycle of the switching transistor and one of the possible drawbacks of this converter is that the switch does not have a terminal at ground [4].

2.1.6.1 Principle of operation

The schematic in figure 2.9 shows the basic boost converter.

With continuous conduction for the Buck-Boost converter \( V_x = V_{in} \) when the transistor is ON and \( V_x = V_o \) when the transistor is OFF. For zero net current change over a period the average voltage across the inductor is zero

![Diagram](image)

Figure 2.9: schematic for buck-boost converter

![Diagram](image)

Figure 2.10: Waveforms for buck-boost converter
\[ V_{\text{on}} + V_{\text{off}} = 0 \]  
(Equation 2.9)

which gives the voltage ratio
\[ \frac{V_o}{V_{\text{in}}} = \frac{D}{1 - D} \]  
(Equation 2.10)

and the corresponding current
\[ \frac{i_o}{i_{\text{in}}} = \frac{1 - D}{D} \]  
(Equation 2.11)

Since the duty ratio "D" is between 0 and 1 the output voltage can vary between lower or higher than the input voltage in magnitude. The negative sign indicates a reversal of sense of the output voltage.

2.1.7 Ćuk converter

The Ćuk converter is a type of DC-DC converter that has an output voltage magnitude that is either greater than or less than the input voltage magnitude, with an opposite polarity. It uses a capacitor as its main energy-storage component, unlike most other types of converters which use an inductor. It is named after Slobodan Ćuk of the California Institute of Technology, who first presented the design in the paper [4].

2.1.7.1 Operating Principle

The buck, boost and buck-boost converters all transferred energy between input and output using the inductor, analysis is based on voltage balance across the inductor. The Cuk converter uses capacitive energy transfer and analysis is based on current balance of the capacitor. The circuit in figure 2.11 is derived from duality principle on the buck-boost converter [2].
If we assume that the current through the inductors is essentially ripple free we can examine the charge balance for the capacitor C1. For the transistor ON the circuit becomes

and the current in C1 is $I_{L1}$. When the transistor is OFF, the diode conducts and the current in C1 becomes $I_{L2}$. 

---

**Figure 2.11: Cuk Converter**

**Figure 2.12: Cuk "On-State"**

**Figure 2.13: Cuk "Off-State"**
Since the steady state assumes no net capacitor voltage rise, the net current is zero

\[ I_{L1} \cdot t_{ON} + (-I_{L2}) \cdot t_{OFF} = 0 \]  

(Equation 2.12)

which implies

\[ \frac{I_{L2}}{I_{L1}} = \frac{(1-D)}{D} \]  

(Equation 2.13)

The inductor currents match the input and output currents, thus using the power conservation rule

\[ \frac{V_o}{V_{in}} = \frac{D}{(1-D)} \]  

(Equation 2.14)

Thus the voltage ratio is the same as the buck-boost converter. The advantage of the cuk converter is that the input and output inductors create a smooth current at both sides of the converter while the buck, boost and buck-boost have at least one side with pulsed current [4].

2.1.8 Flyback converter

The Flyback converter is a DC to DC converter with a galvanic isolation between the input and the output(s). More precisely, the flyback converter is a buck-boost converter with the inductor split to form a transformer, so that the voltage ratios are multiplied with an additional advantage of isolation. When driving for example a plasma lamp or a voltage multiplier the rectifying diode of the Buck-Boost converter is left out and the device is called a flyback transformer.
2.1.8.1 Operating Principle

The flyback converter is an isolated power converter, therefore the isolation of the control circuit is also needed. The two prevailing control schemes are voltage mode control and current mode control. Both require a signal related to the output voltage. There are two common ways to generate this voltage. The first is to use an optocoupler on the secondary circuitry to send a signal to the controller [4]. The second is to wind a separate winding on the coil and rely on the cross regulation of the design.

![Flyback converter diagram](image-url)
2.2 Power LED

Light-emitting diodes (LED) has emerged in recent years as viable sources of light and it’s also extremely durable and has lifetimes exceeding tens of thousands of hours [1]. It has been the choice for automotive interior lighting for years, particularly for signal applications. And now, due to recent advances in solid-state lighting, power LED is being designed in the exterior applications as well. Although used primarily in center high-mount stop lamps (CHMSL) and rear combination lamps, power LED continue to gain ground for most automotive interior and exterior lights [3]. The widespread adoption of solid-state light sources is taking place because of appealing attributes such as small size, robustness, long lifetime and high efficiency.

Automotive manufacturers are attracted by the potential reduction in energy consumption as well as the space savings realized by smaller lighting fixtures. The styling potential of power LED also is a great benefit for consumers, which enables more attractive and distinctive designs [3]. Consumers also benefit from safety aspects of using solid-state signal lighting. For example, faster turn-on of the stop lamps can reduce the risk of rear-ends collisions. And perhaps the most compelling reason for using power LED is their expected reliability and lifetime. These are benefits manufacturers and consumers can both appreciate, as they will potentially significantly reduce replacement and maintenance costs for automotive lighting [3]. Exterior power LED lighting has been increasingly popular on trucks and buses because of the compact size and shock resistance of solid-state lights.
These advantages of the power LED lighting fixtures simplify compliance with various safety regulations. The exterior applications include tail lights, stoplights, marker lights and identification (ID) lights [3]. For example, the National Highway Transportation Safety Administration (NHTSA) has issued a new compliance that truck trailers 80-in. wide or over must have ID lamps mounted over the rear door even if the space available is only 1-in. high [3]. Power LED narrow-rail lamps provide the only solution practical in such minimum-space applications.

As we can see, the power LED is changing the world of lighting systems due to its characteristic and function. The main characteristic of the power LED is:

i. Last generation of Power LED have a luminous efficiency around 45 lm/W, with better performances than incandescent lamps (10 lm/W) or Halogen lamps (20 lm/W). Luminous efficiency in Power LED has been increased in the last 2 years [1].

ii. Power LED operating life is longer than other types of light [1].

iii. Another advantage is the broad temperature operation Range (-40 °C to 120 °C) and the low on-off times, around 100ns [1].

iv. Power LED is a good choice in lighting applications, because they do not need complex power topologies for working (unlike discharge lamps) [1].

The application of the power LED’s can be found in product such as medical instrumentation, general and emergency alarm lighting, design and architectural lighting, interior and runway lights [3].
2.3 MOSFET

The MOSFET (figure 2.16) is a voltage controlled device which characteristic as shown in figure 4b. Power MOSFET is of the enhancement type rather than the depletion type. A sufficiently large gate to source voltage will turn the device on, resulting in a small drain to source voltage [6]. The drive circuit to turn on a MOSFET on and off is usually simpler than that for a BJT.

![MOSFET schematic and v-i characteristics](image)

Figure 2.16: MOSFET

<table>
<thead>
<tr>
<th>Pin 1</th>
<th>Pin 2</th>
<th>Pin 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>G</td>
<td>D</td>
<td>S</td>
</tr>
</tbody>
</table>

Figure 2.17a: MOSFET symbol (n-channel)  
Figure 2.17b: v-i characteristics
In the ON state, the change in VDS is linearly proportional to the change in ID. Therefore, the ON MOSFET can be modeled as an ON state resistance called RDS (ON).

Low voltage MOSFET have on state resistance of less than 0.1Ω, while high voltage MOSFET have ON state resistance of a few ohms [6]. Here are a few list of the MOSFET characteristic for it to be the guidance in switch selection:

I. It’s a very fast switching device which may exceed 100 KHz. For some low power devices (few hundred watts) may go up to MHz range [6].

II. Turning on and off the MOSFET is very simple. It’s only need to provide $V_{GS} = \pm 15V$ to turn on and 0V to turn off. Their gate drive circuit is also very simple.

III. Basically, it’s built in low voltage device. High voltage device are available up to 600V but with limited current and it can be paralleled quite easily for higher current capability [4].

IV. There are internal (dynamic) resistances between drain and source during the ON state that will limits the power handling capability of MOSFET. High losses especially for high voltage device due to RDS (ON) [6].

V. MOSFET is well known to be dominant in high frequency application because of it characteristic to be exceeding 100 kHz switching speed and it also one of the biggest application in switched-mode power supplies [4].
2.4 PIC microcontroller

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1640 originally developed by General Instrument's Microelectronics Division [4]. The name PIC initially referred to "Programmable Interface Controller", but shortly thereafter was renamed "Programmable Intelligent Computer" [4]. PIC are popular with developers and hobbyists alike due to their low cost, wide availability, large user base, extensive collection of application notes, availability of low cost or free development tools, and serial programming (and re-programming with flash memory) capability [4].

![Figure 2.18: PIC microcontroller](image)

2.4.1 PIC16F785 microcontroller

PIC16F785 is a small piece of semiconductor integrated circuits. The package type of these integrated circuits is DIP package. DIP stand for Dual Inline Package for semiconductor IC. This package is very easy to be soldered onto the strip board. However using a DIP socket is much easier so that this chip can be plugged and removed from the development board. PIC16F785 is very cheap. Apart from that it is also very easy to be assembled. Additional components that need to make this IC work are just a 5V power supply adapter, an internal 20MHz crystal oscillator and 2 units of 22pF capacitors. This IC can be reprogrammed and erased up to 10,000 times. Therefore it is very good for new product development phase [5].
2.4.1.1 Feature

The PIC16F785 Flash microcontroller offers all of the advantages of the well recognized mid-range x14 architecture with standardized features including a wide operating voltage of 2.0-5.5 volts, on-board EEPROM Data Memory, and nanoWatt Technology. Analog peripherals include up to 12 channels of 10-bit A/D, 2 Operation Amplifiers, 2 high-speed analog Comparators, and a Bandgap Voltage Reference. Digital peripherals include a standard Capture/Compare/PWM (CCP) module, a 2-phase PWM with asynchronous feedback, a 16-bit timer and 2 8-bit timers [5].

The new PIC16F785 actually reduces the number of devices in a design by including not only the necessary interface peripherals for a SMPS design, but also two channels of analogue pulse width modulation (PWM), two voltage comparators, and two op amps[5].

Now, all the parts needed to implement the analogue control sections of up to two SMPS channels are included in the microcontroller. This means fewer parts to handle, a simpler layout, and even a lower material cost. In addition, the microcontroller control over the SMPS analogue blocks allows control up through a Level 3 design (on/off control, output control, and topology/configuration control), something that is only rarely possible with a separate microcontroller/PWM controller solution [5].
CHAPTER 3

METHODOLOGY

3.1 Overview of Project

![Diagram](image)

Figure 3.1

The whole idea of this project is to design a system that provides a more efficient solution for driving a high power LED by controlling the power LED current and the total amount of power going into the power LED by using PIC microcontroller. This system is designed to provide a more efficient solution for driving a high power LED and increase the efficiency of the power levels required for the power LED to operate.

PIC microcontroller will be used to control the level of voltage so it can produce the desired power LED’s current. It is controlled by setting the duty cycle of the PWM signal generate in the PIC microcontroller at the average amount of time so that the power LED is energized.

The PWM frequency is chosen high enough so that the power LED current is turned on and off at a rate that will not cause the human eye to detect flickering. Through this, the efficiency of the power levels required for the power LED to operate will be increase.
3.2 Hardware Description

The hardware functionality of the buck-boost power Led driver circuit can be divided into four functional blocks:

i. Power Supply
ii. Buck-Boost converter
iii. Power LED driver system
iv. Power LED

3.2.1 Power Supply

Power supply is part of every electronic device, so wide variety of circuit is used to accommodate such factor as power rating, size of current, cost, and desired regulation and so on. A simple way to drop the ac voltage without a bulky and expensive transformer is to use a capacitor in series with the line voltage.

![Figure 3.2: Schematic of power supply](image)

In this project, the power supply were designed as in figure 3.2 were used to implant along with the fixed positive voltage regulator to provide a fixed regulated voltage. Before \( V_i \) entered the voltage regulator, it were filtered first using the capacitor and \( V_o \) produce from the voltage regulator were also filtered again using the capacitor. As you can see, there is has a current sensing resistor located at the negative connection of the power supply input. A low value resistor is used to avoid excessive power...