

Oliver Bunyans LED Bike Light Report

by Oliver Bunyan

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BATTERY LED BIKE LIGHT DESIGN + PROJECT

By Oliver Bunyan



Prifysgol Cymru
Y Drindod Dewi Sant
University of Wales
Trinity Saint David

Introduction

I've been given a task as a student in UWTSD to design a LED smart bike light. We have been studying electronic components and their benefits and uses throughout the first semester and it's now our time to put that knowledge to use with this project.

Within this report some of the tasks I will talk about are -

- Different LED smart bike lights that are already on the market
- PWM Within an LED
- The use of pulse width modulation within the LED
- Information on LED Drivers
- How to drive a LED from a microcontroller
- Commercial LED Modules
- PIC Microcontrollers
- Lithium-ion Batteries
- Different components used within the design of the LED and their usages
- A block diagram of the LED + My circuit design
- A flowchart showing the systems software operation
- A Parts list and costs
- Conclusions and recommendations for future work

Different LED bike lights on the market

There is a massive range of bike lights and brands already available on the market. My plan is to implement my own style and design and add that to the range of lights already available. Some of the brands which are well known for creating very good LED bike lights from Topeak, Lezyne, Blackburn, Cat eye and Bontrager to name a few.

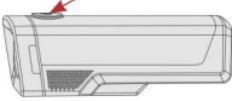
I researched different bike lights and come across a blog displaying multiple lights at different price ranges and with different components and features too. In the blog they talk about the positives of each light and why they believe they're a good light at a good price. From this blog I then come across this light made by Bontrager. Bontrager has a very sturdy and well-built front bike light which is in a blog as one of the best front lights for under £100 therefore it caught my attention and made me look deeper into the light.

[1]

Bontrager ION PRO RT

The Bontrager comes in at £99 and has a wide variety of extra features to make it a smarter L.E.D light than others. It has five different modes and modes for both night rides and day rides and it is USB rechargeable. It is powered by the Cree L.E.D type at 1,300 lumens which it can run on that full-powered mode for 1 and a half hours. The battery it uses is a 4,800 LI-Ion battery. The design is strong and compact, and it also comes with a light mount to fit around handlebars which is adjustable. The light uses one button to be used, Double press of the button will turn the light on and a single press and hold of the button will switch the light off. Short single clicks of the button in between can change the brightness and settings. The light also features a Bluetooth wireless connection that can be used to connect apps such as Garmin to the light and the battery life can be seen and light changing modes can be changed by using this app as opposed to the singular button on the light itself. This is an example of a higher-end bike light with multiple smart features. [2]

In the image below is an example of the different modes that are featured on the Bontrager and the lumens outputs and runtimes of each mode.

Model	Power Button/Status LED	Mode	Max Output (lumens)	Runtime (hours) ²
Ion Pro RT		High	1300	1.5
		Medium	800	3
		Low	400	6
		Night Flash	200	26
		Day Flash	300	22

[3]

The bike light also has the features you realistically need and are going to use, also plenty of different modes to maximise your battery life to suit whatever light intensity or setting you'll need for your current activity. If you're on a long journey of cycling within the day as well as the night, the flashing modes are great as they catch people's eyes more and the durations that the batteries can run at are excellent. As well as the runtimes displayed in the table the light will go into a low battery mode and run for an extended 30 minutes and drop to 50 lumens when the light goes below 5%, this is a very nice feature to give the user that extra bit of light if need be and they are due to run out but still need to use the light to get home. [3]

Power Button/Status LED Color	Battery Life, %
Green Steady	25 to 100%
Red Steady	5 to 25%
Red Flashing	Less than 5%

[3]

Another smart feature of the Bontrager light is the showing of the battery % on the lights power button which has an LED featured within. This is an excellent feature so that the user can constantly see what power % he has left and put the light on the correct mode to maximise battery life if they have a long journey ahead. This is a feature I'd like to include in my design. Other cool and smart features included within the design include using the same L.E.D's on the power button to display lights when the Design is actually charging to tell the user what the charge percentage is on. [3]

Model	Power Button/ Status LED Color	Charge, %	Charge Duration (hours)
Ion Pro RT	Red Flash ¹	<25%	7 ³
	Yellow Flash ¹	25% - 75%	
	Green Flash ¹	75% - 99%	15
	Green Steady ²	100%	

[3]

The table on the previous page taken from the manual, it shows the different LED colours that display when the battery percentage is at different charging points. This is a useful design as the battery life gradually decreases over time especially when left discharged over long periods of time.

The bike light has similarities to the design that I want to use which also features one button which is used to do all the instructions on and within the L.E.D. The light features extra settings such as day and night-time running lights. I like this design as it can maximise power and minimise battery usage from using the lights in the day and at night without getting an opportunity to charge it. I will be looking at implementing this feature within my L.E.D light as it is a very cool and unique instruction to have. The bike light has been designed to work at a higher intensity or beam so that it's more visible at daytime and up to 2km in light distance which makes it more visible in the daytime. As for night-time riding, there's a less bright setting which can give the same amount of visibility distance as the day time but obviously less brightness which in return means less power is being used and the battery is being worked a lot less resulting in the battery lasting longer. The charge time of this battery is 15 hours when using the 2-wire slow (1Hz) USB or a charge time of 7 hours when using the faster 4 wire (2Hz) USB which is the USB that comes when purchasing the light which is a massive decrease in charging time between both. A 500mA charger must also be used with the 4 wire USB to get a full charge within 7 hours as opposed to 15 hours. [3]

"Every model of the lights made by the company Bontrager has been designed to be visible from at least 200metres away." – [3]



[2]

Lezyne Hecto drive 500XL

An example of a cheaper light on the market at £35 is the Lezyne Hecto Drive 500XL. The light has a maximum power of 500 Lumens and has only a 1-hour battery life at this intensity. It has a USB charging point to charge the battery where you plug the light directly into a USB charging port. The light has a unique design that has built-in cooling fins to allow the light to not overheat when working at its full capacity. It has eight different modes on the light to allow from flashing to different light intensities with no flash. [4]

The battery life of the light at different intensities and modes are displayed in the table below.

Runtimes:

- Blast 500lumens = 1hr
- Enduro 200 lumens = 2hrs
- Economy 100 lumens = 4hrs
- Femto 15lumens = 20hrs
- Flash 50lumens = 13.5hrs
- Day Flash 500lumens = 5.75hrs
- Pulse 50lumens = 15hrs

[4]

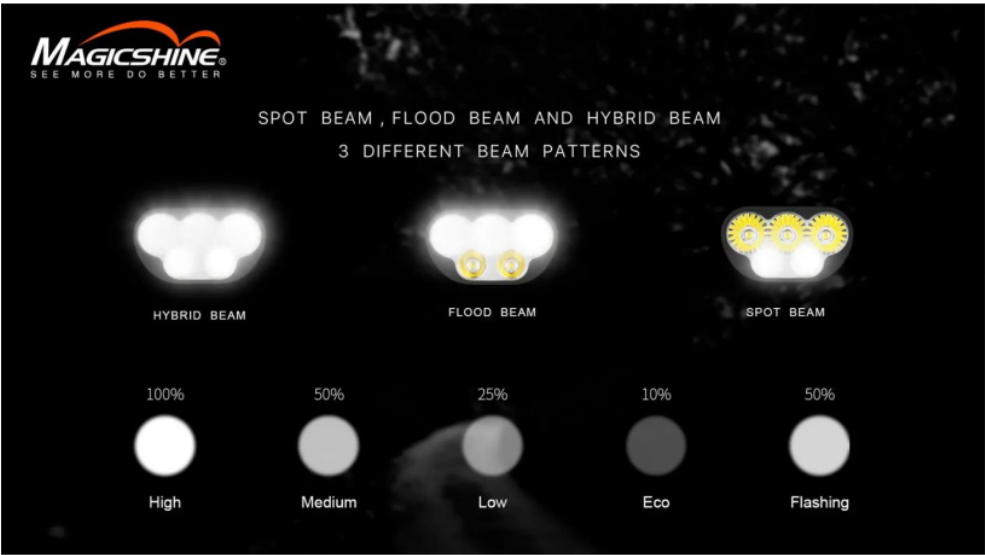
As displayed the light doesn't have a great deal of run time on constant light modes and higher lumen modes. A maximum runtime of 20hrs on 15 lumens is a good length of time but with a very poor brightness of the light. The maximum constant light mode feature is 4hrs but at only 100 lumens will not be great also, as shown from the different modes and battery life's in each mode of the Bontrager light previously spoken about you can see how one has a massive price difference to the other. Although the light does have plenty of modes that can be used as well as a day flash mode which is a very good feature and makes the light more useable in the daytime while also not overrunning the battery life down using it in a constant light mode. A positive of this light is that it has a max charge time of 2.5 hours which is not bad for how much battery life you can get out of it in certain modes. [4]



Magicshine Monteer 6500S ZEUS

A more powerful and expensive bike light is the Magicshine Monteer 6500S ZEUS. This bike light is excellent for darker more intense rides like night mountain biking through the trees. It generates a lot more light compared to the others mentioned. The price is also a lot more compared to the other mentioned sitting at £280 but you get what you pay for in terms of power within the light. It runs a huge 10,000mAh battery which is USB charged using the type C plug. It has a massive 6500 lumens to light the whole trail which consists of three CREE xhp 50.2 LEDs and then another 2 LED's below them which are CREE XM-L2. The FLOODLIGHT which is the three top LED's on generate 5000 lumens when on alone. The spotlights which are the bottom two generate 1500 lumens when on alone. It has multiple different modes such as 100% light intensity, 50%, 25% and 10% and different flash modes. At full brightness, the light can stay on for around 2 to 1 and a half hours. It has a handlebar mount to mount the light to the bike. The light is widely used and talked about due to its

brightness and also the area of light which is given off, which is a lot more spread out as opposed to focus which works great for what it's used for. Some of the negatives which come with the light are no display to show the battery life of the light when out to make sure it is charged enough and a mode display to show what mode it is in. The battery then consists of four cells which are 18650 cells combined to a 10000 mAh total. As the battery is high powered a lot of heat can be generated therefore the company magic shine have thought through this and designed the light housing with a hard anodised aluminium which covers the light housing for protection. This is to maximise the heat dispersion. [5]



[5]

Hope District+ Rear Light

Upon further research, I come across the hope district+ Rear light which is highly regarded on the rear bike light market. It has multiple different modes and can have an extended battery run time compared to its previous model. The LED has six different power levels as well as three flash settings and 3 static different brightness levels. The LED uses a 7.4V Li-ion battery which is compatible with both battery packs such as 2600mAh and 5200mAh battery pack. It also has a piggyback option which means the light can be charged on the go while being used. The light's battery duration ranges from 15hrs to 200 hrs depending on the light intensities and modes used. The charge time for the battery is 3 hours from a fully discharged state while using the 2600mAh li-ion battery pack. The light has a massive degree of visibility at 270 degrees. The light uses 3 Osram oslon LED's and has a light output of 105 measured lumens and 135 generated lumens. The light sits on the more expensive side of rear bike lights at £72 but has everything you need and more to be the perfect rear bike light. The features within the light and light modes are the right number of modes needed to get the most out of the light that is needed. [6]



[6]

Pulse width modulation in an LED.

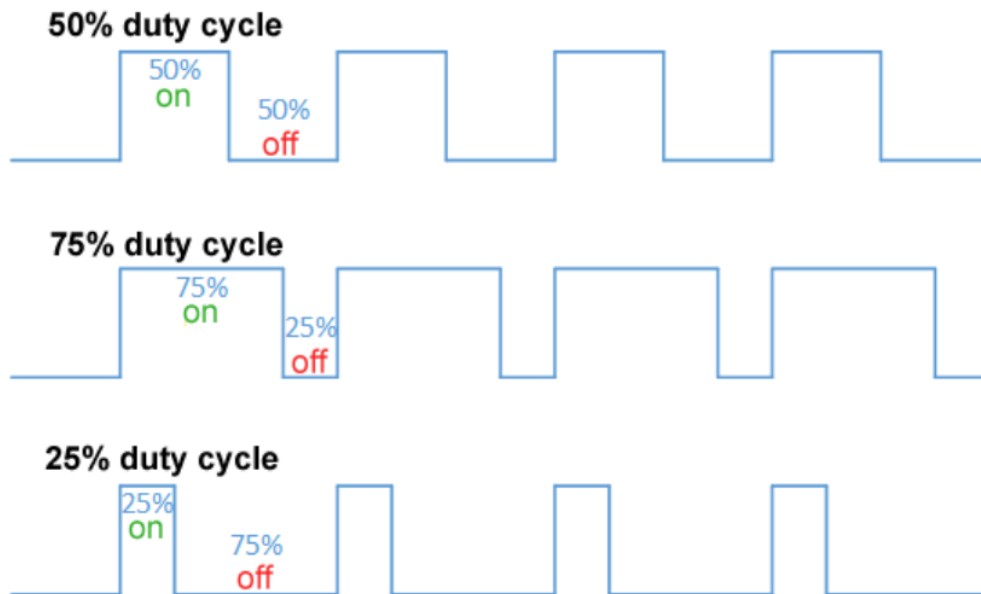
Pulse width modulation is used within an LED to display different brightness and controls in the LED's. These are beneficial because they use less power when the duty cycle is in lower states, instead of the power being used 100% all the time. Also, you can't reduce the voltage and current going through them as easy as this method. Most Microcontrollers are digital also which means they only have an 'ON' state and an 'OFF' State therefore there are no states in-between to be able to change light intensities or brightness's. Therefore, using PWM we can achieve analogue states by the percentage of our duty cycles using this method. As well as being able to portray the LED in analogue states we can use still use the PWM method and display the light as it is fully on therefore not using 100% of the power and still getting the desired effects. [7]

The way PWM works is that the voltage is fast switched on and off, which is too quick for the human eye to see which looks as if the light never goes off. The duty cycle must be at least 50Hz therefore 50 times a second for the human eye not to see the on and off switching but this can vary between different people.

The power consumption is lower also when the duty cycle is lower, therefore, these are ideal for using in LED bike lights as batteries voltage is limited and you won't have maximum power on all the time when out on a bike ride, therefore, helping the battery last longer. [7]

The brightness of the LED is controlled by different duty cycles which are typically measured in %. A 100% duty cycle will mean that the light will be on 100% of the time with no off periods. Therefore, if there was a 5V supply supplying an L.E.D 5V will be put into that L.E.D constantly, therefore, using lots of power. If there was a duty cycle of 50% then only that means the power will be on 50% of the time and be of 50% of the time. Meaning the light intensity will be half of what it would be while on a 100% duty cycle.

This system is useful as it means power is not left on completely 100% meaning having a high level of current. A lot of the current will be limited through a resistor and dispersed as heat which can cause problems to the circuit and cause overheating and wasted power. Using the PWM system the fast on and off switches averages out the power usage therefore the current is regulated more. [7]



[8]

This is an example of three different duty cycles. The first cycle at the top shows the 50% duty cycle where the power is on and off at a ratio of 1:1 and therefore the light is at a 50% intensity and the power dissipated is 2.5V if there is a 5V supply. [9]

The second duty cycle is 75% therefore the light is $\frac{3}{4}$ of its full brightness. This means the power that would be being used it $\frac{3}{4}$ of the 5V supply. [9]

The last duty cycle shows power on only 25% of the time and off for the remaining 75%. This will give a light intensity of 25% and a power outage of only $\frac{1}{4}$ of the supply. [9]

LED Drivers

Within my LED bike light, it must feature a LED driver. An LED driver is used almost all the time with LED's but a lot of the time you can buy LEDs with an integrated driver within therefore there is no need to buy the component individually. They are typically used to convert alternating current into direct current for the LED's or just Direct current to direct current but a constant current or constant voltage depending on the type you choose. As power can alternate and can be interrupted which will then affect the LED causing flickering, general degraded performance, and colour changes the LED Driver is brought in to prevent these from happening by supplying a constant and uninterrupted power supply. The way they can get this uninterrupted power supply is by allowing for changes in the temperature and the electrical conductivity of the LEDs in the circuitry. An LED driver can act like a Transformer where it receives high voltage and outputs low voltage for the LED to run off. LED drivers also can be used to control the brightness of LED's. [10]

There are multiple different LED driver features & types but the one I would practically be looking at is the COB LED. Constant current LED drivers would be best suited for this type of driver. This means that there will be a steady current given to the LED's, but the voltage received within the driver will vary therefore the wattage within each LED will change. Constant voltage drivers are typically used for more power-hungry LED's systems such as high-definition displays in public spaces and billboards backlighting. [10]

It is important I implement a LED driver within my circuitry so that I do not burn out the LED. The LED can be burnt out due to drawing into much current and causing the LEDs to heat up. The forward voltage which is needed to power the LED changes with temperature, therefore when the temperature of the LED increases it causes the forward voltage to decrease which will then cause the LED to heat up as it draws more current due to the less forward voltage. The process of this is called a thermal runaway and it is prevented by using an LED driver therefore they are crucial to any circuit using LEDs. [11]

How to drive an LED from using a microcontroller.

There are multiple ways of driving LEDs from using microcontrollers. The way that's best suited to me to drive the LED is using a microcontroller and using PWM within the microcontroller. The embedded computer is very small and compact therefore ideal to fit within a small LED light such as the one I am designing. Using the microcontroller, I will need other components such as an LED Driver, current limiting resistors, Schottky and an inductor. I will connect the LEDs to the output pins of the microcontroller which use have PWM integrated within the chip. A transistor or a MOSFET will be used with the LED driver to help with the fast switching which is to be used for the PWM. Within the microcontroller, there will also be a 555 astable oscillator timer which will help with setting the delays and PWM for the LED. The LED's brightness is proportional to the current it's receiving. The current power will be increased or decreased depending on how long the state of the chip is on or off using the PWM method. Therefore, we can increase and decrease the brightness of the LED without the need for a variable resistor. Transistors are good to be used for fast switching as they can handle high frequencies and they can be used to control the amount of frequency going through the LED, they allow a small amount of current to control a large amount of current. A code is written into a microcontroller which is what is used to control the PWM of the circuit, an example where this is needed is using the Arduino board. Arduino's have most of the components needed for an LED bike light circuit built within and needs to be coded before use to suit what's needed.

The method I plan to use is an LED Driver being driven by the output PWM pin from the microcontroller. The Internals of the led driver will have all the components needed to ensure that the switching can be done at the frequency needed for the PWM, from the driver I will then have a couple of components such as 2 CREE LED's in parallel, an inductor, a Schottky diode, a resistor and also a current limiting resistor.

Commercial LED Modules

There are multiple LED modules out there that can be used to be put within my bike light. LED modules usually contain either one or more LED's which are contained within a board or a casing. These boards or casings usually have internal components within to ensure the board doesn't overheat and limits current. The LED modules are plugged into the power supply or connected to LED drivers which will power all the LED's within the module. An example of some LED's modules are:

V

LedEngin Inc LZ1-10R102-0000, LZ Circular LED Array, 1 Red LED

LED ENGINE

RS Stock No.: 905-3882 | Mfr. Part No.: LZ1-10R102-0000 | Brand: [LedEngin Inc](#)



1 In stock - FREE next working day delivery available

Units

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Price Each

£8.22
(exc. VAT)

£9.86
(inc. VAT)

Units	Per unit
1 - 9	£8.22
10 - 49	£7.44

This LED module features one RED LED which can be useful for having an indicator for showing a battery is running low for example, or even that a battery is charging when plugged in. This type of LED is also widely used in rare LED bike lights as they use a red light as opposed to white light. This Module has numerous features such as a Zener diode for ESD protection, low thermal resistance, High luminous flux density and high efficiency. It also features three sets of anode and cathode solder pads to connect the module into the circuitry. It is a constant current module therefore it would need a constant current LED driver to drive it correctly. It has a voltage rating of 3V and a maximum current of 1.5A therefore it would be ideal for low voltage circuitry. [12]

Another module example is:

LedEngin Inc LZC-B3MA07, LZC Circular LED Array, 12 Amber, Blue, Green, Red LED

LedEngin Inc LZC-B3MA07, LZC Circular LED Array, 12 Amber, Blue, Green, Red LED LED ENGIN

RS Stock No.: 829-0882 | Mfr. Part No.: LZC-B3MA07 | Brand: LedEngin Inc



Available to back order for despatch 14/06/2022

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1

+

Units

Back order

Price Each

£49.21

(exc. VAT)

£59.05

(inc. VAT)

Units	Per unit
1 - 4	£49.21
5 - 9	£44.29
10 - 14	£39.29

This module is made by the same company as the previous company and is an excellent module that allows for numerous different lights to be shined from the same LED. It features a 40W 12 die LED emitter with high efficiency, high luminous efficiency, and very low thermal resistance. Every die within the LED is individually addressed and there's a huge range of colours on the emitter such as red, deep red, blue, amber, green and violet. This module can be very useful depending on what it's used for. For a bike light, you'd most likely not choose this as the colours it can array will be wasted as for a bike light mostly white and red will be the only light colours used. This light also uses 40W of power which is a lot of power for a small LED light. [13]

CREE LED's

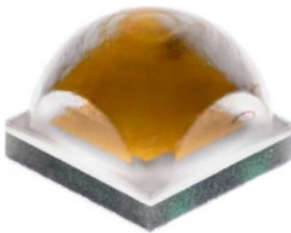
For my LED bike light so far I have not looked at LED modules such as the ones above but instead, I have been looking at CREE LED's with the module not included. The module can be bought afterwards, and the LED put onto the module. CREE LED's have a wider PCB area than the COB LED's and is better at dispersing heat as it has more surface area to disperse the heat. CREE LED's tend to have a longer lifespan too as opposed to COB LED's.

The LED I have looked at is the 3.25V White LED 3535 SMD, CREE LED Xlamp XP-L. This LED has a high luminous flux of 1058 and a forward voltage of 3.25V. It also has a maximum forward current of 3A where it will be at its brightest. This is an excellent LED that supplies a lot of light for such a small feature. At 1050 mA it has a forward voltage of 2.95 but a max forward voltage of 3.25A. For me to get the most lumens out of this LED I will need to supply the LED with 3A. My plan was to add three of these LEDs in series meaning I'd need a forward voltage of 9.75V to power all three at once. When looking more into the specifications of this LED I will most likely either use fewer LEDs or change the LED to a different one as the current and voltage I need to supply could be tricky within such a small circuitry as the LED bike light. [14]

[Home](#) > [Displays & Optoelectronics](#) > [LEDs & LED Accessories](#) > [LEDs](#)

3.25 V White LED 3535 SMD, Cree LED XLamp XP-L XPLAWT-00-0000-0000V5051

RS Stock No.: 9080705P | Mfr. Part No.: XPLAWT-00-0000-0000V5051 | Brand: Cree LED



1194 in stock - FREE next working day delivery available

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10

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Price Each (Supplied on a Reel) Quantities below 150 on continuous strip

£2.11

(exc. VAT)

£2.53

(inc. VAT)

Units	Per unit
10 - 38	£2.11

COB LED's

COB LED's are another LED that can be used for lighting applications of whatever you choose to design. They have chips within each of the diodes and their chip controls each individual diode. They produce roughly the same heat as CREE LED's but cannot disperse this heat as well as CREE LEDs. They have multiple diodes on one panel and because of that, it looks as if it's one diode in a very large size as opposed to multiple. [14]

PIC Microcontrollers

I have visited a well-known site called microchip which is very useful for researching different PIC's needed for whatever components you are controlling or design you are creating. I am looking at different PIC's that could be used within my circuitry. Some of the PIC's relevant to me I have come across are:

PIC16F18323.

The first PIC I found is the PIC16F18323. This PIC is very useful for what I am going to be doing and the components needed. It features a lot of relevant stuff which will be used for my circuitry. Some of the KEY aspects which I will need for my circuitry that it features is:

- "2x 10-bit PWMs
- 256B EEPROM
- Flash Program Memory with self-read/write capability
- 2x 8-bit Timers (TMR0/TMR2)
- Enhanced Power-On/Off-Reset
- The PIC has an operating range of 1.8V to 5.5V
- CPU speed of 8 MIPS
- Flash Program memory size of 3.5KB
- Temp Range -40 to 125
- Pin Count 14
- 256B SRAM Memory
- 10 bit analogue to digital convertor" [15]

This has all the features needed for my circuitry and more therefore it is a great option to be used within my circuit. The timers will be used to control the duty cycle of the main L.E.D as well as the battery indicating LED. The operating range is perfect for the 3.7V battery I am going to use. There is a large amount of EEPROM memory for tasks to be read into. PWM features within the Chip will also be used to control the dimming and flashing of the Main LED as well as the battery light indicator LED. CPU speed is more than enough to instruct all the tasks within the light. The program memory time within is large enough to store tasks done by the CPU. The data memory is also plenty of memory for the tasks within the Circuitry. The chip features a time base for PWM Function. The PIC also features an Analogue to digital converter which will be used within my circuit to monitor the battery charge. [15]

PIC16F15344

This is another PIC that caught my eye and can be very much used for my circuit as it is well suited with the right internal components needed.

Some of the key features are:

- “Flash Program Memory with self-read/write capability
- eXtreme Low Power (XLP)
- 4x 10-bit PWM's
- 1x 8-bit Timers (TMR0/TMR2)
- Enhanced Power-On/Off-Reset
- 8 MIPS CPU Speed
- 7KB Program memory size
- 20 Pin count
- 17 ADC Channels
- Temp Range -40 to 125
- Operating voltage 1.8 - 5.5V
- 512 bytes of RAM”

[16]

This PIC also has all the relevant features for my circuitry needs therefore can be useful to be used for my system. This PIC is very similar to the first PIC that I had stated with slightly different values such as memory size and pin counts. This PIC also has more RAM available than the previous PIC stated. [16]

PIC16F1769

This Microcontroller also stood out to me as being used for my circuit

Some of the key features are:

- “Flash Program Memory with self read/write capability
- 128 B of non-volatile data storage
- 100K erase / write cycles
- PWMs: two 10-bit and two 16-bit
- High Current Drive I/Os: Up to 100mA capacity
- 8 MIPS CPU Speed
- Temp Range -40 to 125
- Operating voltage 1.8 - 5.5V

- 20 Pin count
- 14KB Program memory size
- 12 ADC Channels
- 1024 Bytes of RAM memory
- 128B Non-volatile data storage"

[17]

Once again there are some key features on this PIC that will be useful to my Microcontroller and very similar components to the two previous PIC's shown but varying in sizes of RAM, ROM and BIT sizes with PWMs. A difference with this circuit compared to others is the High current drive input/outputs as opposed to the others which is a nice feature to have within this circuit. They all feature good operating voltages as well as a good temperature range to withstand overheating within the circuitry and the different weather conditions they the bike light can be used in. These are the three PIC's I have narrowed down too, with one potentially being used for my circuit. [17]

Lithium-ion Batteries

Lithium-ion batteries are now widely used and gained popularity in most consumer electronics. They have a lot of pros as opposed to other rechargeable batteries available on the market.

Some of the key points are that their Eco-friendly, Lightweight and Compact, they have a higher energy density than other batteries for their size, more charge cycles, Low self-discharge rate, and low maintenance as opposed to other batteries available on the market. [18]

Firstly, the batteries are safer for us humans, animals, and the environment than the previous batteries which were widely used such as lead-acid and nickel-cadmium batteries. Secondly, a massive advantage of using lithium-ion batteries is their size. The battery size has decreased massively while still able to produce the same power output or more than a lead battery 2-3x the weight and size. [18]

For example, a Lithium-ion 18650 battery has a length of 70mm and diameter of 18mm and is able to produce 2600 mAh capacity at 3.7V weighting at 0.045kg. Whereas you have a lead battery which is 6V and a 1300 mAh capacity which is weighing at 0.3kg and dimensions of 98 x 25 x 56mm which is marginally bigger and a lot heavier than the lithium-ion battery stated but with half the mAh capacity. [18]

Also as opposed to size, lithium-ion batteries are capable of storing and able to release large amounts of energy in a small size. This means that compared to Lead batteries they can last much longer between charges and still produce the high performances they're capable of. [18]

The discharge rate of a lithium-ion battery is relatively slow as opposed to other rechargeable batteries. This is massive for say a LED bike lights such as the ones that were designed because if they're not used as frequently and you go to use them, you're going to want it to be as full of a charge as you'd left it. The batteries self-discharge at about a maximum of 5% within the first 24 hours before then discharging at around 1-2% a month. Whereas within a lead battery it's around 5% a month and can increase if the temperature where the battery is stored increases. [18]

Another advantage is the low maintenance needed when using lithium-ion as opposed to other rechargeable batteries. This is to do with the memory effect which can happen on some rechargeable batteries such as recharging the battery when it's on a certain % and then when using the battery again the battery only using the % of battery that was left before the charge and not the full charge the battery has. Other batteries need regular maintenance to ensure that this does not happen whereas lithium-ion doesn't. [18]

A disadvantage of using lithium-ion is the protection needed with the battery, such as the batteries being overcharged or being discharged too far. The circuitry is needed within the battery to ensure this doesn't happen which is widely available, but it takes the way the

simplicity of just using the battery. The circuitry within will just cut and the supply to it when it's fully charged instead of overcharging and the same applies when the battery voltage gets too low the battery will cut off as opposed to discharging too much. [19]

The bonus with the lithium-ion is that they can give a constant output of their voltage stated and stay at that point throughout discharge whereas other batteries voltage deteriorate as the battery life decreases therefore you may be left with not enough voltage to drive some components within the circuitry.

USB Charging for lithium-ion battery

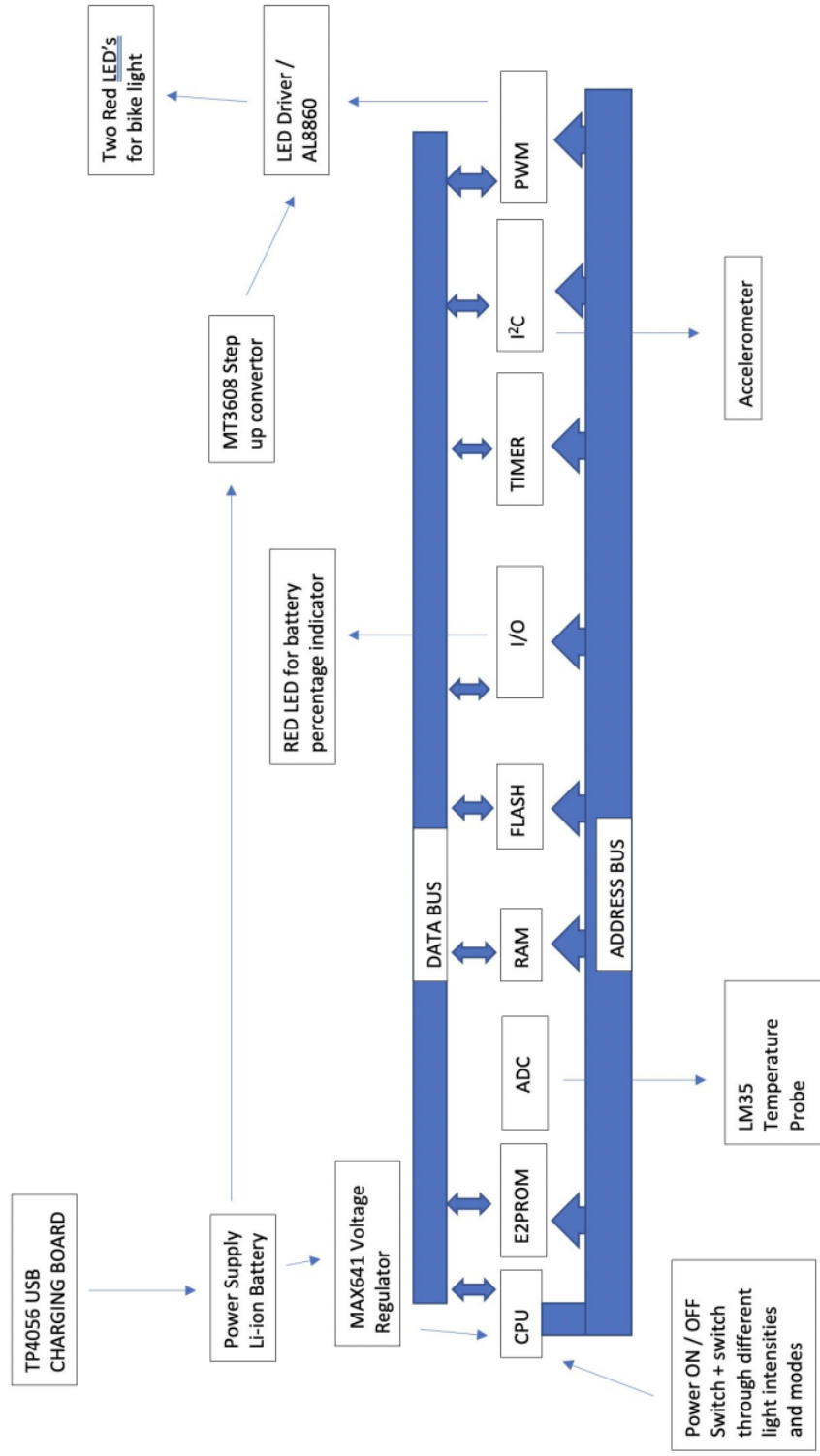
For my circuitry, I'd like to implement USB charging to charge the Lithium-ion battery stored within the LED light. There are advantages and disadvantages of using a USB to charge the lithium-ion batteries as opposed to a battery charging pack. One advantage is that you do not need to buy an extra charger if using USB charging such as micro-USB. Although it will take longer to charge the Batteries using the USB method as opposed to an AC powered battery charger. [20]

Faster charging is what most people would prefer but faster charging reduces the battery life therefore slower charging is better suited to ensure the battery life has the longest life that it can have and will need to be changed less. Also, the faster charging will cause the battery to heat up which causes deterioration in the battery, this is due to higher voltage and current to increase the charging speed.

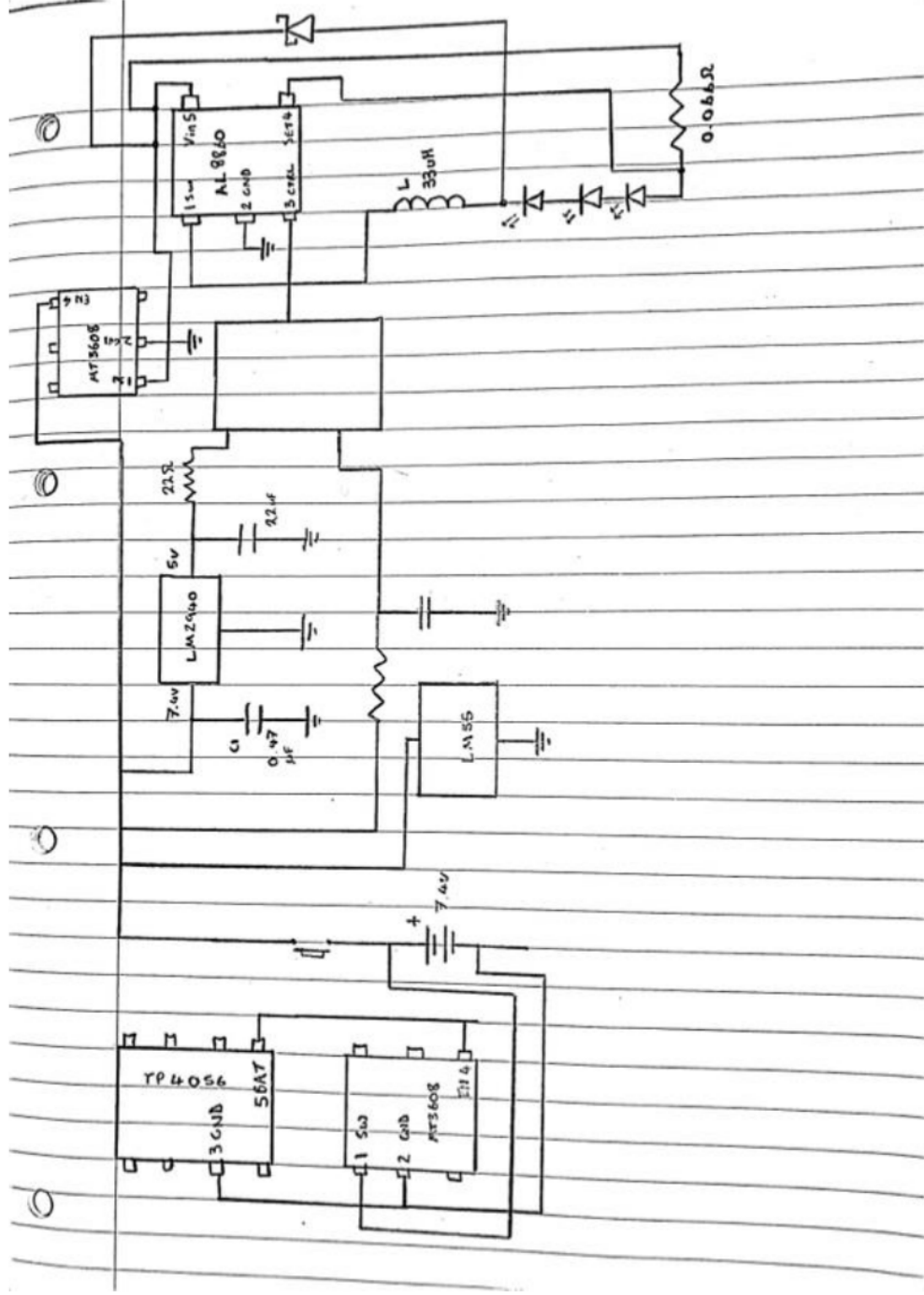
I am looking at using a Micro USB charging port within my light circuit to charge up the lithium-ion battery. I like this option due to its simplicity and fewer components needed. The charge is charged slower but more suitable for the battery to keep its longevity. I have found a circuit that uses USB charging. I have also found a circuit to be used as a boost converter to increase the voltage from the USB to match with the voltage needed to charge the battery.

As I will be using Lithium-ion batteries in series which is 7.4V, the USB charging only disputes 5V therefore I will need to use a boost converter to increase the voltage to the correct voltage needed. The TP4056 micro-USB lithium battery charging board is what I am to use to charge the battery. Between this charging board and the battery, there is going to be an MT3608 DC-DC boost converter with adjustable step-up module voltage so that the power can be boosted from the charging board to suit the power needed. A potentiometer is used on the boost converter to adjust the output voltage from the converter.

LED Circuit Block diagram



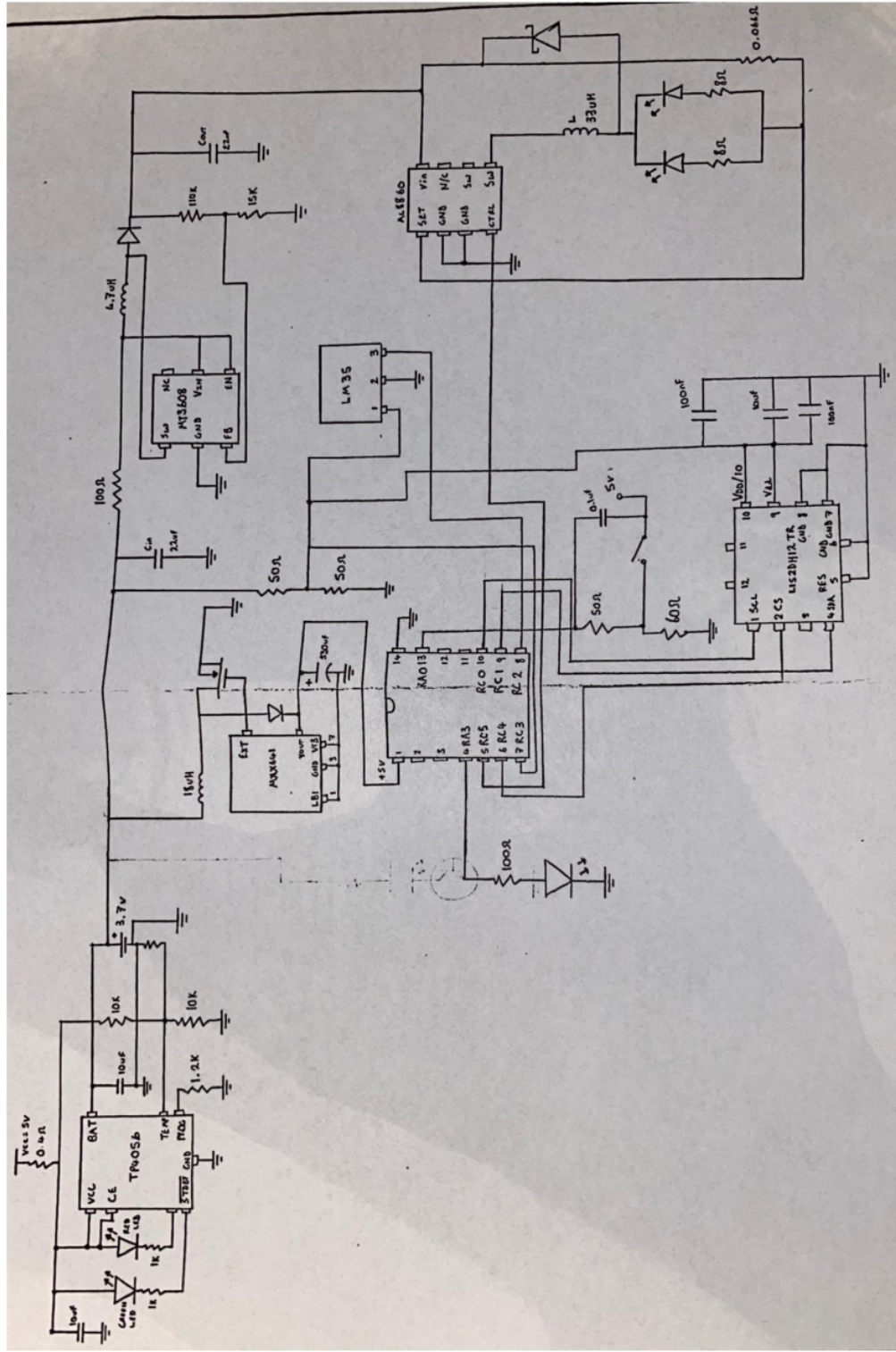
Partial first design of LED Circuit



On the previous page is my first design of the LED circuit. It was not fully complete and also not correct either which I learnt along the way upon further research of components. I have changed numerous things within my new circuit compared to the old circuit due to not needing some components so trying to narrow down the components as I have limited space within my light. I also opted to run the lights in series as opposed to parallel as I was initially doing therefore there was no need for the two batteries, and I've narrowed it down to the one 3.7V battery. I also had not chosen a PIC at this point in time therefore the blank box in the sketch was to be the PIC microcontroller.

On the previous page is my finished LED circuit. It is a lot different to my first design and I have changed a couple of components as well as adding in an accelerometer into the circuit. I thought I'd finished the circuit with this design with looking into it further I noticed a mistake which was driving the battery indication LED directly from the battery which would've been above the max voltage of the LED, therefore, damaging it. I then decided to change the design slightly and use a different LED such as the next model.

Finished LED Circuit



On the previous page is my final design which has the changes of the LED being driven from the PIC as opposed directly from the battery through a transistor.

Circuit Operation

The way the circuit and LED bike light is to operate is by firstly pressing and holding the switch for 2 seconds to power it up. The 5V's taken also from the voltage regulator will travel through the switch and through to the pin, the capacitor and resistors in series are put in to stop switch bounce from happening where there are spikes in the voltage from the switch the 50 and 60ohm resistor in series ensures only a current of 45mA is driven to the pin which is within the maximum current threshold of each pin. When this happens one of the I/O pins will set the accelerometer Chip select pin to high so that it is now on. The voltage will flow through to the voltage step-up MT3608 and the output voltage will be then at 5V as opposed to 3.7V. The 5V will then power up the LED driver which will allow current to flow through the lighting circuit and the two LED's in parallel, the current will be limited to each LED by an 8-ohm resistor where the max current each LED can take is 0.7A and the current I'll be supplying to each individually is 0.625A. The inductor will carry charge on the off periods of the PWM which will be pulsed into the LED driver from the microcontroller to the CTRL pin of the driver. The Schottky diode is used as their good in fast switching applications due to the energy stored in them and help produce less noise on the output waveform.

The PWM will supply the duty cycle to the LED driver and the LED driver will power the LED circuit as it should be with different light intensities on the LED. Each time the switch is pressed when the light is on will flick it into a different mode. With 3 different brightness modes and 3 different flashing modes, the PWM will change within the microcontroller and send the right duty cycle to the LED for each mode.

The LM35 measures temperature and converts it to voltage. When the temperature rises too high the circuit will cut out to allow it to cool down and not overheat and damage components. The lm35 is powered by half of the battery voltage using two of the same value resistors in series to divide the input voltage, by using a lower voltage the accuracy of the temperature conversions can be more accurate than using higher voltages. I also am measuring the battery voltage by taking another supply from the resistors in series meaning I have an output of half of the voltage to one of the analogue to digital converters. When the battery % goes under 20% of its max charge the RA3 output pin will send a constant high signal to the LED. As this happens the battery indication LED will come on and display for the user to see that the battery is running low. I used a 100-ohm resistor again here to limit the current 43mA to the LED as the LED also needs a forward current of 25mA.

The TP4056 chip is used to charge up the lithium-ion battery when needed. A 5V supply voltage from a USB will be given to the chip and the circuitry will then charge up the lithium-ion battery, the RED LED on the circuit board will be illuminated when the battery is charging, and the green LED will illuminate once the LED is fully charged. The circuit will not overcharge the lithium-ion battery which is a maximum charge of 4.2V. The 1.2k resistor was chosen to allow the circuit to supply 1A to charge the battery. The lithium-ion battery

has onboard circuitry to make sure it is not overcharged or discharged too far also. The other components around the TP4056 are needed to ensure the circuit is connected correctly and works correctly.

The MAX641 chip is a voltage regulator and is used to provide a regulated voltage of 5V to the chip. This can ensure there is a constant 5V at the chip and the voltage to the chip will not go down when the batteries charge goes lower. The MOSFET and the capacitors help with stepping up the voltage, and all the components are needed to complete the chip so it can be used correctly.

The MT3608 has components around it to ensure that it works correctly, the capacitors are used to store energy so that the voltage can be stepped up. The Accelerometer also has external connections such as capacitors which are used to store energy and help the accelerometer perform its operations correctly.

The pins were chosen by looking at the datasheet of the microcontroller and understanding what pins could be used for what instruction.

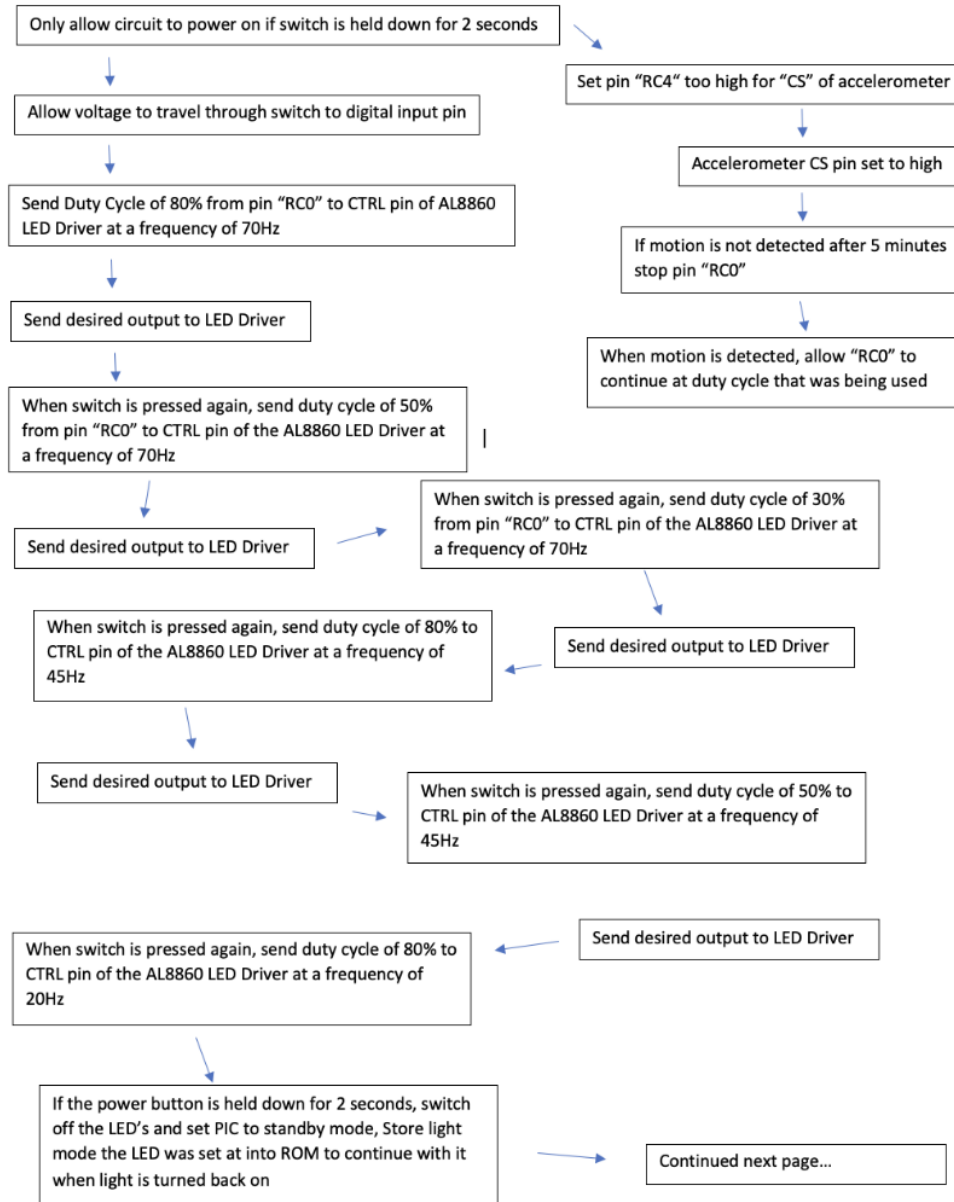
RC0, RC1 was used for the I²C clock and I²C data pins for the accelerometer. RC2 was used for the ADC channel for the LM35 temperature probe. I know this from the data found on the datasheet below.

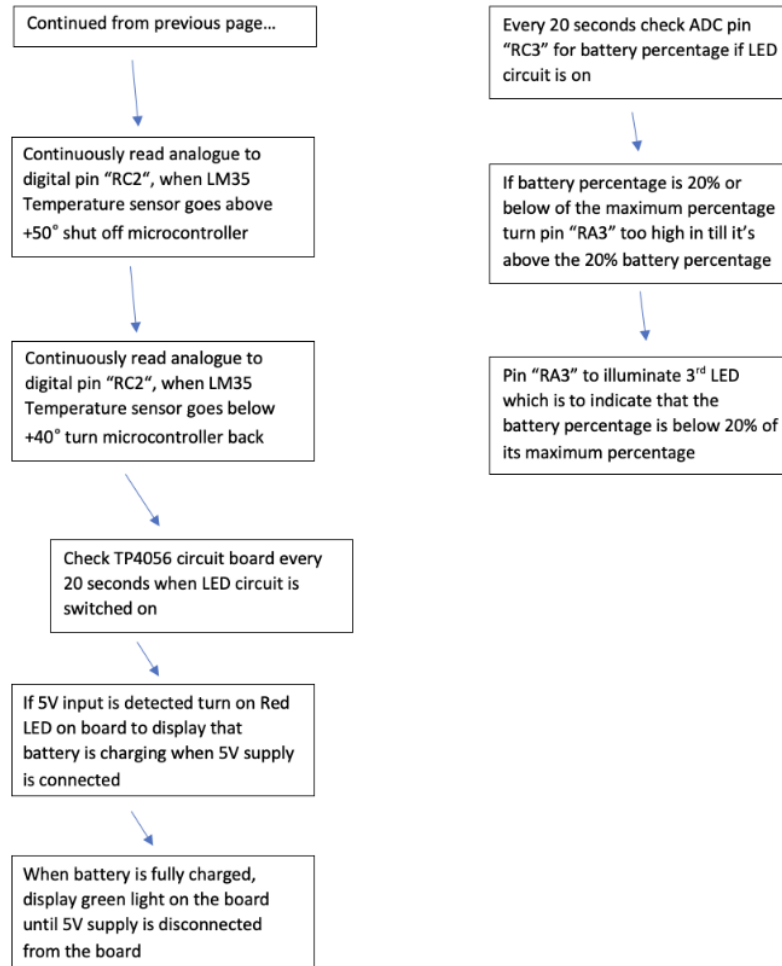
Name	Function	Input Type	Output Type	Description
RC0/ANC0/C2IN0+/SCL1 ⁽¹⁾ /SCK1 ⁽¹⁾	RC0	TTL/ST	CMOS	General purpose I/O.
	ANC0	AN	—	ADC Channel C0 input.
	C2IN0+	AN	—	Comparator positive input.
	SCL1	I ² C	OD	I ² C clock.
	SCK1	TTL/ST	—	SPI clock.
RC1/ANC1/C1IN1-/C2IN1-/SDA1 ⁽¹⁾ /SDI1 ⁽¹⁾ /CLCIN2 ⁽¹⁾	RC1	TTL/ST	CMOS	General purpose I/O.
	ANC1	AN	—	ADC Channel C1 input.
	C1IN1-	AN	—	Comparator C1 negative input.
	C2IN1-	AN	—	Comparator C2 negative input.
	SDA1	I ² C	OD	I ² C data.
	SDI1	TTL/ST	—	SPI data input.
RC2/ANC2/C1IN2-/C2IN2-/MDCIN1 ⁽¹⁾	CLCIN2	TTL/ST	—	Configurable Logic Cell source input.
	RC2	TTL/ST	CMOS	General purpose I/O.
	ANC2	AN	—	ADC Channel C2 input.
	C1IN2-	AN	—	Comparator C1 negative input.
	C2IN2-	AN	—	Comparator C2 negative input.
	MDCIN1	TTL/ST	—	Modular Carrier input 1.

RC3 was used for another ADC channel. RC4 was used to set the Chip select of the accelerometer to high, using it as a general-purpose I/O. RC5 was used as the PWM pin to send the duty cycle to the LED driver. RA3 was used to send a high output signal to the transistor to allow current to flow through the transistor from collector to emitter.

RC3/ANC3/C1IN3-/C2IN3-/MDMIN ⁽¹⁾ /CCP2 ⁽¹⁾ /CLCIN0 ⁽¹⁾ /SS1 ⁽¹⁾	RC3	TTL/ST	CMOS	General purpose I/O.
	ANC3	AN	—	ADC Channel C3 input.
	C1IN3-	AN	—	Comparator C1 negative input.
	C2IN3-	AN	—	Comparator C2 negative input.
	MDMIN	TTL/ST	—	Modular Source input.
	CCP2	TTL/ST	—	Capture/Compare/PWM2.
	CLCIN0	TTL/ST	—	Configurable Logic Cell source input.
RC4/ANC4/CLCIN1 ⁽¹⁾	SS1	TTL/ST	—	Slave Select input.
	RC4	TTL/ST	CMOS	General purpose I/O.
	ANC4	AN	—	ADC Channel C4 input.
RC5/ANC5/MDCIN2 ⁽¹⁾ /CCP1 ⁽¹⁾ /RX ⁽¹⁾	CLCIN1	TTL/ST	—	Configurable Logic Cell source input.
	RC5	TTL/ST	CMOS	General purpose I/O.
	ANC5	AN	—	ADC Channel C5 input.
	MDCIN2	TTL/ST	—	Modular Carrier input 2.
	CCP1	TTL/ST	—	Capture/Compare/PWM1.
	RX	TTL/ST	—	EUSART asynchronous input.
VDD	VDD	Power	—	Positive supply.
VSS	VSS	Power	—	Ground reference.
RA3/MCLR/VPP	INT	TTL/ST	—	External interrupt.
	RA3	TTL/ST	CMOS	General purpose I/O.
	MCLR	TTL/ST	—	Master Clear with internal pull-up.
	VPP	HV	—	Programming voltage.

Flowchart of LED circuit





This is the flowchart of my circuit on this page and the previous.

Parts list of LED Bike Light.

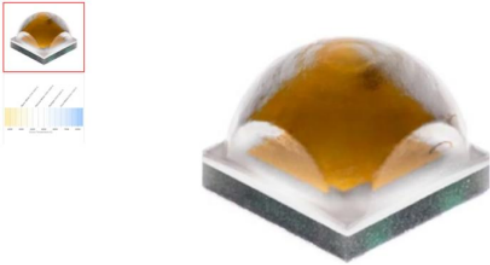
LED

I Initially choose this LED which had a 3.25 Forward voltage, and at its maximum brightness, it was 1058 lumens needing 3A of current to power. [21]

[Home](#) > [Displays & Optoelectronics](#) > [LEDs & LED Accessories](#) > [LEDs](#)

3.25 V White LED 3535 SMD, Cree LED XLamp XP-L XPLAWT-00-0000-0000V5051

RS Stock No.: 9080705P | Mfr. Part No.: XPLAWT-00-0000-0000V5051 | Brand: Cree LED



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[21]

I planned to have 3 in series meaning I'd need a forward voltage of 9.75A and id have 3174 lumens within the bike light which would've been massive for such a small light. I also worked out Id' need roughly 10.2375 watts of power per led therefore 30.7125Watts of power from the LED alone.

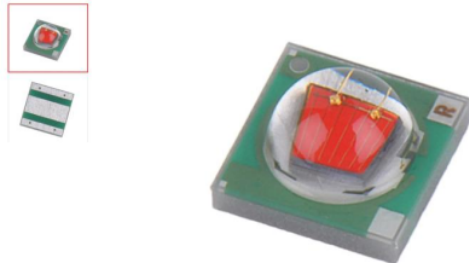
I initially took the 10.2375 watts of the singular battery thinking id need only that amount for all the LED's therefore I added another battery so that there were enough watts available to power them. Initially, I only had one battery which only had 9.62W therefore I added another battery so that I had 19.24W of power available. I also chose an LED driver which could only output a maximum current of 1.5A therefore I wouldn't have been able to use the LED's maximum brightness and get the best out of them as possible.

On top of the theory above, I planned to use white LED's as shown and use a RED film across the plastic casing to display them as RED LED's but on further thought, I didn't account for losing light intensity due to the film not displaying all the range of colour's through therefore it was pointless trying to power these high powered and brightness LED's and not get the maximum out of them.

I turned my head to lower-powered LED's which were RED LED's such as these.

2.1 V Red LED 3535 SMD, Cree XLamp XP-E XPERED-L1-0000-00801

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[22]

These LED's have a lower forward voltage of 2.1V per LED as opposed to the 3.25V of the previous. They have a max current rating of 0.7A at their brightness. They are a lot less bright than the other LED with a max lumen of 73.9 per LED. Also, they're RED LED's therefore there's no need for a red film and losing brightness by doing that method. These require a lot less power to drive which I worked out:

At MAX current/brightness: $2.1V \times 0.7A = 1.47W$ per LED

At HALF max current/brightness: $2.1V \times 0.35A = 0.735W$ per LED. [22]

Therefore, there is a lot less wattage needed to drive the LED's now. As the LED driver can provide a maximum current of 1.5A also the LED's fit within the current the LED driver can provide. I plan to connect these LED's in parallel as opposed to in series therefore I need 1.4A across them both to ensure they are lit, using a resistor to each LED to limit the current to 0.7A to each. I will now have a max lumen of 147.8 with both LED's.

LED For Battery indication

2.8 V Red LED 5mm Through Hole, Panasonic LN21RPX

RS Stock No.: 169-7960 | Mfr. Part No.: LN21RPX | Brand: Panasonic



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*price indicative

View all LEDs

This is the LED I have chosen to display a light when the battery % goes below a certain threshold. I chose this LED as it has a forward voltage of 2.8V, a low forward current of 25mA and is ideal for what it's intended for.

I put it in series with a 100ohm resistor to limit the current to it to 43mA. The PIC at high voltage output level will drive the LED with 4.3V, which I have gotten the figure by using the datasheet which says to -0.7 from the VDD of the PIC. [23]

LED DRIVER

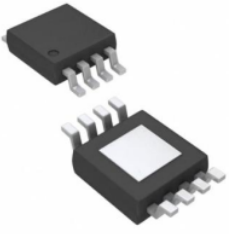


Image shown is a representation only. Exact specifications should be obtained from the product data sheet.

AL8860MP-13

Digi-Key Part Number

AL8860MP-13DITR-ND - Tape & Reel (TR)
AL8860MP-13DICT-ND - Cut Tape (CT)
AL8860MP-13DIDKR-ND - Digi-Reel®

Manufacturer

Diodes Incorporated

Manufacturer Product Number

AL8860MP-13

Supplier

Diodes Incorporated

Description

IC LED DRVR 8MSOP

Manufacturer Standard Lead Time

30 Weeks

Detailed Description

LED Driver IC 1 Output DC DC Regulator Step-Down (Buck) Analog, PWM Dimming 1.5A 8-MSOP-EP

Customer Reference

Customer Reference

Datasheet

 Datasheet

The LED Driver I plan to use is the AL8860MP-13. I had initially looked at other LED drivers before deciding on this driver as it has all the features and amount of power and current

outputs needed for my circuit. It provides a maximum output of 1.5A which is within the current output that I need for my two LED's. I will be using the MSOP-8EP version of the chip which can supply the output current up to 1.5A. The input voltage range is between 4.5V to 40V therefore I will use a step-up converter to boost the 3.7V of my battery to power so that it has enough power to power the chip. [24] [25]

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DATA SHEET

LM78L 100-mA Fixed Output Linear Regulator datasheet (Rev. L)

Online data sheet

Product details

Technical documentation

Design & development

Ordering & quality

Support & training

Product details

Parameters

Package | Pins | Size

Features

Description

Output options	Fixed Output
Iout (Max) (A)	0.1
Vin (Max) (V)	30
Vin (Min) (V)	6.7
Vout (Max) (V)	15
Vout (Min) (V)	5
Fixed output options (V)	5, 6.2, 9, 12, 15
Noise (uVrms)	40

INPUT

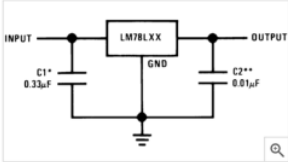
C1* 0.33uF

LM78LXX

GND

C2** 0.01uF

OUTPUT





The voltage regulator I was going to use is the LM78L, I choose this regulator as it was within the voltage threshold that I was to supply it with and outputs a low current which is suitable for maximum currents of a PIC. Other versions of this Regulator supplied up to 1A output current meaning id must put a resistor in to limit the current such as the first voltage regulator I chose which was the LM2940. It also has an excellent operating range of -40 to +125 degrees which is suitable for the pic. As I no longer need to step the voltage down for PIC I need to now look at getting a step-up voltage regulator instead. [26] [27]

Step-Up Voltage Regulator

MAX641ACSA+

Boost (Step Up) Switching Regulator, Fixed, 2V-16.5Vin, 5V out, 45 kHz, NSOIC-8



Image is for illustrative purposes only. Please refer to product description.

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Manufacturer Part No:

MAX641ACSA+

Order Code:

2513960

Technical Datasheet:

 [MAX641ACSA+ Datasheet](#)

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With some research, I found an alternative to the step-down voltage regulator and found this step-up voltage regulator which will allow me to step up the voltage from 3.7V to 5V to give the pic a stable voltage. The Regulator has a low output current also of typically 0.135mA and 0.4mA max therefore its suitable for the PIC. [28] [29]

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This is an excellent charging board I found which is suitable to charge my battery up which is powering my circuit. It features an LED to show when the battery is charging as well as a blue LED to show when the battery is fully charged, the module's full charge is 4.2V which ensures that the Lithium-ion battery isn't charged to higher than it needs to be. It has linear charging therefore suitable to not charging the battery too quickly and causing it to

deteriorate over time due to charging too quickly and has a maximum output of 1A which can be altered to suit when the Rprog resistor size is altered. The module is used to recharge 3.7V batteries. [30] [31] [32]

NPN Transistor

Diodes Inc ZTX450 NPN Transistor, 1 A, 45 V, 3-Pin E-Line

RS Stock No.: 922-7759 | Mfr. Part No.: ZTX450 | Brand: DiodesZetex



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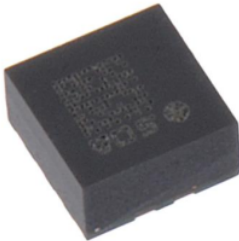
*price indicative

I had chosen a transistor that I'd planned to use to control the LED that is to shine when the battery percentage goes below a certain %. This was not what I needed to do therefore I am not now using this component.

Digital Accelerometer

LIS2DH12TR STMicroelectronics, 3-Axis Accelerometer, I2C, SPI, 12-Pin LGA

RS Stock No.: 878-7465 | Mfr. Part No.: LIS2DH12TR | Brand: STMicroelectronics



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I decided to also put in my system an accelerometer. I chose this accelerometer as it can use the I2C ports within my microcontroller connected to the digital pin, has a low voltage range 1.71V to 3.6V and has lots of other features which make it suitable for my circuit. Using this will allow the light to go off if there's no motion after a set amount of time and then turn back on when it detects motion again.

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This is the step-up voltage converter I am going to use, and it converts a lower DC voltage to a higher one of your choice using a potentiometer on the module. I needed to use this to step up the voltage of the USB charging device to be able to charge up the 2 Batteries in series I was going to be using which amounts to 7.4V and the USB charging device can only output 5V. Although after some thought to saving the number of components that need to be used, I changed my mind to use only one battery which would allow me to use fewer components. I still need one of these converters to convert the voltage from the batteries into the LED Driver as the LED requires at least a minimum of 4.5V to be functional therefore I limited the amount of these components I needed to 1 instead of the 2 initially. [33]

Within the LED driver loop I needed a Schottky diode, an inductor, and a resistor to allow the Diode to circulate the maximum current of 1.5A.

Inductor

[Home](#) > [Passive Components](#) > [Inductors](#) > [Power Inductors](#) > [SMD Power Inductors](#)

7447773330

Power Inductor (SMD), AEC-Q200, 33 μ H, 1.45 A, Shielded, 2.1 A, WE-PD, 7.4mm x 7.3mm x 4.5mm



Image is for illustrative purposes only. Please refer to product description.

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I used this inductor as 33uH because this was the lowest size advised using on the datasheet of the LED Driver. The higher the inductor was more suited for higher voltages which I am not using so this was fine to be used. It also has a saturation current of 2.1A therefore it could withstand the currents put through it by the LED driver. [34]

0.066 Ω Resistor

I also used within the circuit LED drivers' internal loop a resistor to limit the current. I choose the 0.066 Ω resistor as I looked through the LED drivers datasheet and found that this was the correct resistor size to allow the LED driver to drive the maximum amount of current through the circuit which is 1.5A.

[Home](#) > [Passive Components](#) > [Resistors - Fixed Value](#) > [Current Sense SMD Resistors](#)

ERJL06UF66MV

SMD Current Sense Resistor, 0.066 ohm, ERJL06, 0805 [2012 Metric], 250 mW, $\pm$ 1%, Thick Film



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Panasonic

Manufacturer:	PANASONIC
Manufacturer Part No:	ERJL06UF66MV
Order Code:	3336521
Product Range	ERJL06
Technical Datasheet:	ERJL06UF66MV Datasheet
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Delivery

This resistor is suitable for the driver also it has a low power wattage of 250mW.

LED Current Configuration

The nominal average output current in the LED(s) is determined by the value of the external current sense resistor (R_S) connected between VIN and SET and is given by:

$$I_{OUT(NOM)} = \frac{0.1}{R_S}$$

The table below gives values of nominal average output current for several preferred values of current setting resistor (R_S) in the typical application circuit shown on page 1.

R_S (Ω)	Nominal Average Output Current (mA)
0.066	1500
0.1	1000
0.13	760
0.15	667
0.3	333

[35]

Here is the information from the datasheet that helped me come to my decision. [35]

Schottky Diode

Lastly, I choose a Schottky diode for the LED driver loop and this is the one I went with. I chose this diode as it has a low forward voltage of 670mV and a very low reverse leakage current. These are good to be used with high-speed switching applications due to the energy stored within them. They also produce less noise which will help with the waveforms of the output. [36]

[Home](#) > [Semiconductors](#) > [Discrete Semiconductors](#) > [Schottky Diodes & Rectifiers](#)

STMicroelectronics 150V 3A, Schottky Diode, 2-Pin DO-201AD STPS3150RL 

RS Stock No.: 795-8662 | Mfr. Part No.: STPS3150RL | Brand: STMicroelectronics



550 In stock - FREE next working day delivery available

- 25 +

Units

Add to basket

[Check stock levels](#)

Price Each (in a Pack of 25)
£0.262
(exc. VAT)

£0.314
(inc. VAT)

Units	Per unit	Per Pack*
25 - 100	£0.262	£6.55
125 - 225	£0.246	£30.75

[View more](#)

[36]

LM35 Temperature Sensor

Texas Instruments LM35DZ/NOPB, Temperature Sensor 0 → +100 °C ±0.6°C
Voltage, 3-Pin TO-92

RS Stock No.: 533-5907 | Mfr. Part No.: LM35DZ/NOPB | Brand: Texas Instruments



Discontinued product

Alternative

This product is not currently available. Here is our alternative recommendation.



Texas Instruments
LM35DZ/NOPB, Temperature
Sensor 0 → +100 °C ±0.9°C
Analogue, 3-Pin TO-92

RS Stock No.
922-4836

Price Each (in a Pack of 10)

£1.205
(exc. VAT)

£1
(inc. VAT)



I also decided to add a temperature sensor into my circuit to measure the heat dissipated within the circuit. I will then have it set so that when the circuitry gets too hot it'll shut off and cool down to stop it from overheating. [37]

Tactile switch

IP67 Black Cap Tactile Switch, Single Pole Single Throw (SPST) 50 mA @ 24 V dc 

RS Stock No.: 765-1585 | Mfr. Part No.: 5GTH935+1SS09-15.0 | Brand: MEC



32 in stock - FREE next working day delivery
available

2 Units

Add to basket

Check stock levels

Price Each (in a Pack of 2)

£2.85
(exc. VAT)

£3.42
(inc. VAT)

Units	Per unit	Per Pack*
2 - 18	£2.85	£5.70
20 - 38	£2.725	£5.45

I decided to go with this switch to control the instructions within the circuitry and light. I decided on this because it is big and extruded so easy to press when needed when cycling or in the dark and struggling to see the button. It also has a massive operating temperature of -40 to +160 degrees which means it'll withstand all the temperatures it may need to go through. Also, I chose this because it has an IP rating of IP67 which means it can withstand all weather conditions. The 6 means the effect against solids and the 7 is the effect against liquids. [38]

- “6
Dust Tight
No ingress of dust; complete protection against contact.”
- “7
Immersion up to 1m
Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).”

[39]

RS Pro lithium-ion battery

RS PRO, 3.7V, 18650, Lithium-Ion Rechargeable Battery, 2.6Ah

RS Stock No.: 880-1558 | Brand: RS PRO



2479 In stock - FREE next working day delivery available

1 Units

Add to basket

[Check stock levels](#)

Price Each

£6.89

(exc. VAT)

£8.27

(inc. VAT)

Units	Per unit
1 - 4	£6.89
5 - 9	£6.47

[View this category](#)

This is the battery I have chosen to use to power my circuit. It has 2600aH of power and is a 3.7V battery. I chose this battery as it has great power and also has a built-in PCB that controls stuff within the battery such as ensuring the battery is never discharged fully or overcharged. It cuts off the battery if the voltage drops below 2.5V and also if it exceeds 4.25V. [40]

The battery can take 9.62Watts of power.

At max current, each LED will take a maximum of 1.61W each therefore they are well within the constraints of the battery. The PIC and other components within the circuitry will take a load but the LED's are the biggest load and are well below the max wattage of the battery therefore the battery is suitable.

PIC16F18323

After some research on different microcontrollers and their components, I decided to go with this one.



PIC16F18323

Status: In Production.

[Download Data Sheet](#) [Documentation](#) [Symbols](#)

PIC16F18323 microcontrollers feature Analog, Core Independent Peripherals and communication peripherals, combined with Extreme Low Power (XLP) for wide range of general purpose and low power applications. The Peripheral Pin Select (PPS) functionality enables pin mapping when using the digital peripherals (CLC, CWG, CCP and PWM) to add flexibility to the application design.

Demonstration Platform
Internet of Things Sensor Badge with interactive control via motion, multiple

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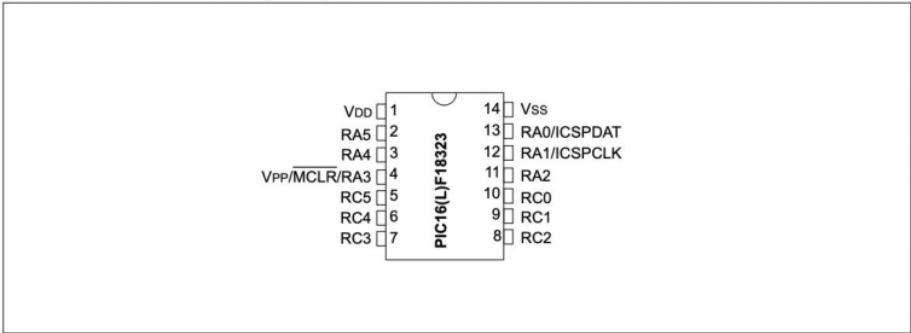
[Programming Services](#)

Product Features

I decided on this one it had all the features needed for my circuitry and more. It had an excellent amount of RAM at 256B which is more than enough needed. It has two 8 bit timers. The EEPROM has 256B also which is excellent to store instructions in for the circuit. An 11 channel ADC is more than enough therefore two of those pins will be used. It also has 2 PWM pins which are exactly what I need. The operating range is within my limits and the Temperature range is wide enough to ensure it can withstand the colder weather as well as the warm weather. [41]

This is the PINOUT of the PIC and the table to show which inputs and outputs can be connected to which pins.

FIGURE 2: 14-PIN PDIP, SOIC, TSSOP



[41]

TABLE 2: 14/16-PIN ALLOCATION TABLE (PIC16(L)F18323)

IO ⁽²⁾	PDIP/SOIC/TSSOP	UGFN	ADC	Reference	Comparator	NCO	DAC	DSM	Timers	CCP	PWM	CWG	MSSP	EUSART	CLC	CLKR	Interrupt	Pull-up	Basic
RA0	13	12	ANA0	—	C1IN0+	—	DAC1OUT	—	—	—	—	—	—	—	—	—	IOC	Y	ICDDAT/ICSPDAT
RA1	12	11	ANA1	VREF+	C1IN0- C2IN0-	—	DAC1REF+	—	—	—	—	—	—	—	—	—	IOC	Y	ICDCLK/ICSPCLK
RA2	11	10	ANA2	VREF-	—	—	DAC1REF-	—	TOCKI ⁽¹⁾	—	—	CWG1IN ⁽¹⁾	—	—	—	—	INTT ⁽¹⁾ IOC	Y	—
RA3	4	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	IOC	Y	MCLR Vpp
RA4	3	2	ANA4	—	—	—	—	—	T1G ⁽¹⁾ SOSCO	—	—	—	—	—	—	—	IOC	Y	CLKOUT OSC2
RA5	2	1	ANA5	—	—	—	—	—	T1CKI ⁽¹⁾ SOSCIN SOSCI	—	—	—	—	—	CLCIN3 ⁽¹⁾	—	IOC	Y	CLKIN OSC1
RC0	10	9	ANC0	—	C2IN0+	—	—	—	—	—	—	—	SCK1 ⁽¹⁾ SCL1 ^(1,3,4)	—	—	—	IOC	Y	—
RC1	9	8	ANC1	—	C1IN1- C2IN1-	—	—	—	—	—	—	—	SDI1 ⁽¹⁾ SDA1 ^(1,3,4)	—	CLCIN2 ⁽¹⁾	—	IOC	Y	—
RC2	8	7	ANC2	—	C1IN2- C2IN2-	—	—	MDCIN1 ⁽¹⁾	—	—	—	—	—	—	—	—	IOC	Y	—
RC3	7	6	ANC3	—	C1IN3- C2IN3-	—	—	MDMIN ⁽¹⁾	—	CCP2 ⁽¹⁾	—	—	SS1 ⁽¹⁾	—	CLCIN0 ⁽¹⁾	—	IOC	Y	—
RC4	6	5	ANC4	—	—	—	—	—	—	—	—	—	—	—	CLCIN1 ⁽¹⁾	—	IOC	Y	—
RC5	5	4	ANC5	—	—	—	—	MDCIN2 ⁽¹⁾	—	CCP1 ⁽¹⁾	—	—	—	Rx ⁽¹⁾	—	—	IOC	Y	—
VDD	1	16	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VDD
VSS	14	13	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	VSS
OUT ⁽²⁾	—	—	—	—	C1OUT	NCO	—	DSM	TMR0	CCP1	PWM5	CWG1A	SDA1 ⁽²⁾	CK	CLC1OUT	CLKR	—	—	—
	—	—	—	—	C2OUT	—	—	—	—	CCP2	PWM6	CWG1B	SCL1 ⁽²⁾	DT	CLC2OUT	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	CWG1C	SDO1	TX	—	—	—	—	—
	—	—	—	—	—	—	—	—	—	—	—	CWG1D	SCK1	—	—	—	—	—	—

[41]

I will use this to help me configure my circuit and wire it up correctly to the correct ports on the PIC.

I can also see here the maximum current per pin which is 250mA and the max voltage per pin.

35.0 ELECTRICAL SPECIFICATIONS

35.1 Absolute Maximum Ratings⁽¹⁾

Ambient temperature under bias..... -40°C to +125°C

Storage temperature -65°C to +150°C

Voltage on pins with respect to VSS

on VDD pin

PIC16F18313/18323 -0.3V to +6.5V

PIC16LF18313/18323 -0.3V to +4.0V

on MCLR pin -0.3V to +9.0V

on all other pins -0.3V to (VDD + 0.3V)

Maximum current

on VSS pin⁽¹⁾

-40°C ≤ TA ≤ +85°C 250 mA

+85°C < TA ≤ +125°C 85 mA

on VDD pin⁽¹⁾

-40°C ≤ TA ≤ +85°C 250 mA

+85°C < TA ≤ +125°C 85 mA

on any I/O pin ±50 mA

Clamp current, I_K (V_{PIN} < 0 or V_{PIN} > VDD) ±20 mA

Total power dissipation⁽²⁾ 800 mW

[41]

Price List

I have made an estimation of the price of the circuit. I have put in the prices of all of the IC's within the circuit and some of the individual components.

Lithium-ion battery = £6.89

Max641 Voltage regulator = £3.93

TP4056 USB charger = £1.49

MT3608 Step up convertor = £2.45

LM35 Temperature sensor = £1.205

AL8860 LED Driver = Unknown (average LED driver £1)

LIS2DH12TR Accelerometer = £1.58

RED LED for battery indication = 0.15

2x RED main LED's for circuit = £4.44

33uH Inductor = £1.58

Schottky Diode = £0.262

0.066 Ω Resistor = £0.168

Tactile switch = £2.85

These are the main components within my circuitry, and it amounts to = **£28**

I will then allow for another £5 to be added on top to add the small components such as capacitors and resistors which are all very cheap components.

Conclusion

Overall, I was happy with how my circuit turned out and the features I had applied to it. When researching existing lights already on the market at the start gave me an idea of what I wanted to do with my own design and what I wanted to put on to the light in terms of features and different modes etc. Therefore, I took ideas from others I'd researched as well as implemented my own idea such as an accelerometer to the circuit which wasn't commonly done on the LED bike lights.

After a lot of research, I'd finally come up with a design that I thought I was happy with but upon further research, I realized that I was going down the wrong route and that my circuit was incorrect to what I wanted it to do and in terms of values of different components and ensuring everything was able to withstand what was being powered through all of the components. I then went back to the drawing board and came up with a slightly revised circuit with changes which would mean narrowing down the number of components I'd needed.

In the future, if I was to have another project like this, I would make sure I understand all the components and features I am applying to the circuit before applying them then realizing that I do not need them, therefore wasting time and having to redo circuits. I would also try and focus solely on the task and not get lost going down a trail into certain components that I do not need to do for this assignment, this made me lose a lot of time on information that in the end did not even feature in my final report. I would also focus a lot on gathering information from watching videos as I found this benefited me more than reading notes online.

I enjoyed the project writing this report and bettering my knowledge on the subject and the components featured within my circuit.

Changes I'd like to make to my LED circuit in the future would include a higher luminosity Bike light with limited features such as the number of components on my circuit now. This was the only negative I'd have on my circuit now as I'd have liked it to be brighter but when its needing to be brighter more calculations need to be done to ensure it has enough power to run the two lights, meaning more batteries and more components.

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Oliver Bunyans LED Bike Light Report

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FINAL GRADE

GENERAL COMMENTS

Instructor

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OLIVER BUNYAN

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ENGAGEMENT WITH LITERATURE

 Very extensive list of research material looked at. For L6 work (next year) ensure you try and ALSO add things like published research papers/white papers investigating things like human perception to flashing lights. death rates of cyclists, etc etc. - Added more academic content rather than all of it being purely technical.

75

KNOWLEDGE AND UNDERSTANDING

 Pretty good level of knowledge and understanding demonstrated in the general concepts.

75

COGNITIVE AND INTELLECTUAL



Could have done a little more explaining WHY you went and chose the methods you did end up using over others, however you have obviously identified positive features etc of the various researched devices.

68

PRACTICAL APPLICATION



A few things in the final circuit would need refining, but given the scope and level required for this assignment - a good effort. The flowchart shows that many key areas are being considered.

62

TRANSFERABLE SKILLS



Generally well laid out and presented. An excellent level of content. Good use of images etc. Could have benefited from a table of contents and numbering the various sections. Try not to use the informal 1st person so much "I did this ... I did that" - you will need to write in the 3rd person for your L6 project report etc.

68