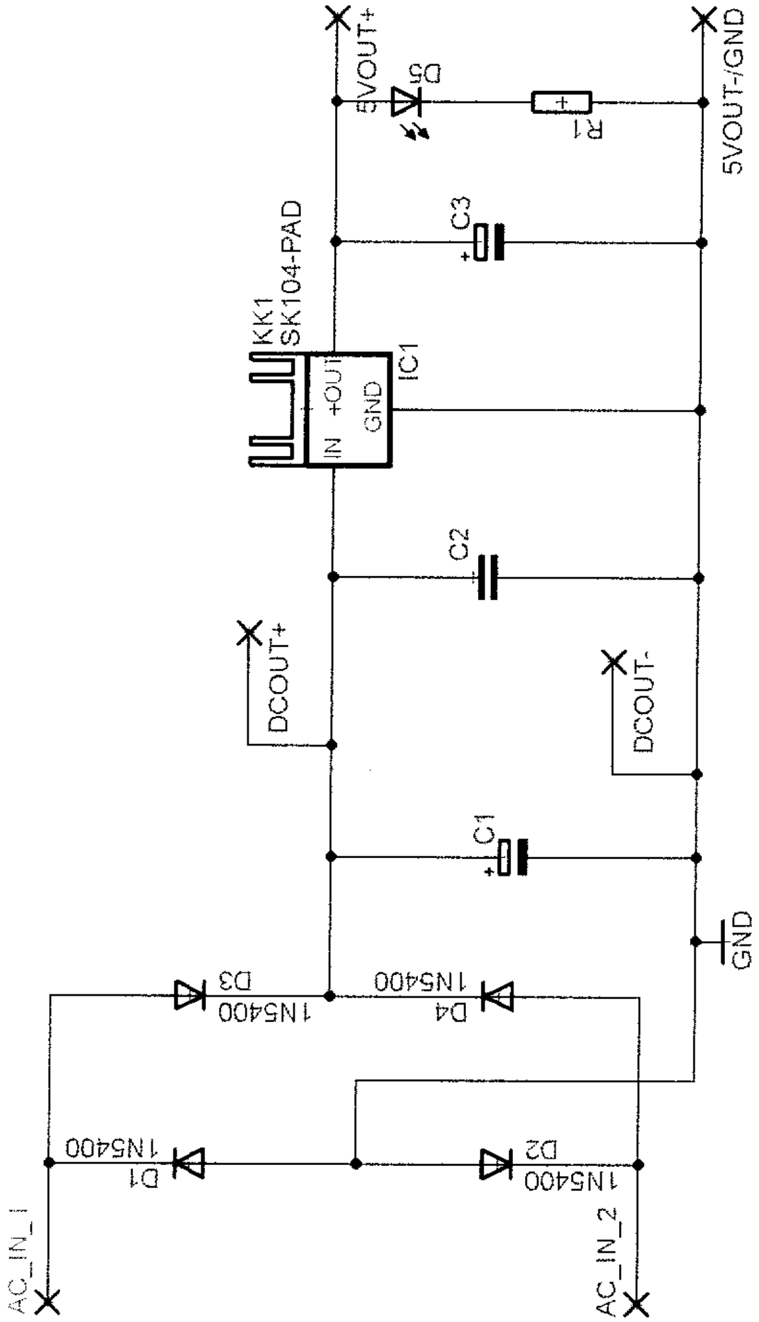

Electronics Subsystems Report

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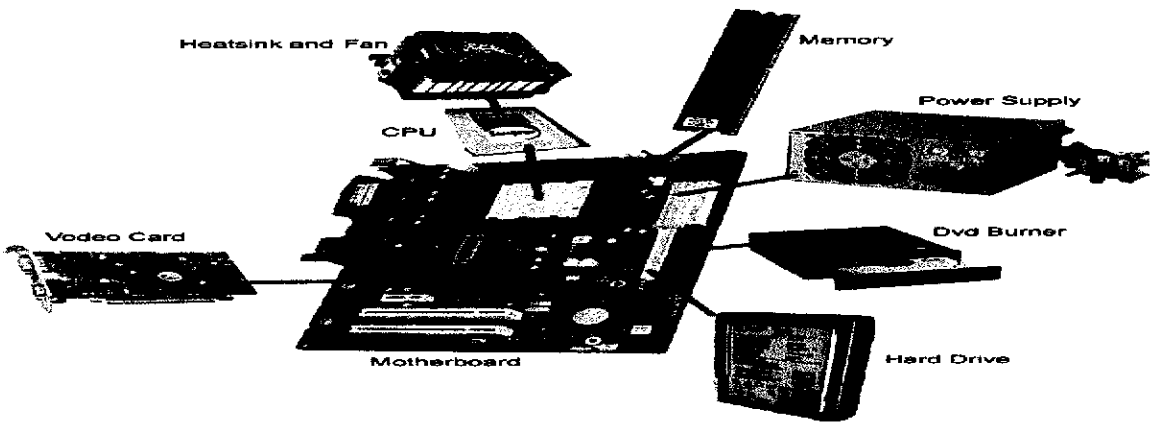
Contents

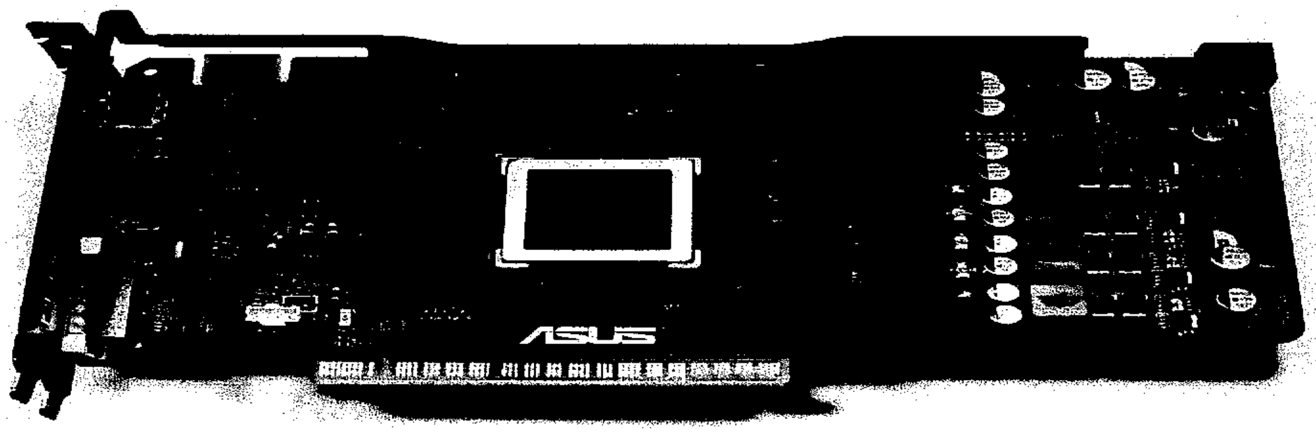
Systems and Subsystems

A system is a group of interdependent components (usually subsystems) that work together to carry out a process or task, all systems contain inputs, processing, and outputs. An example of a system is a computer.

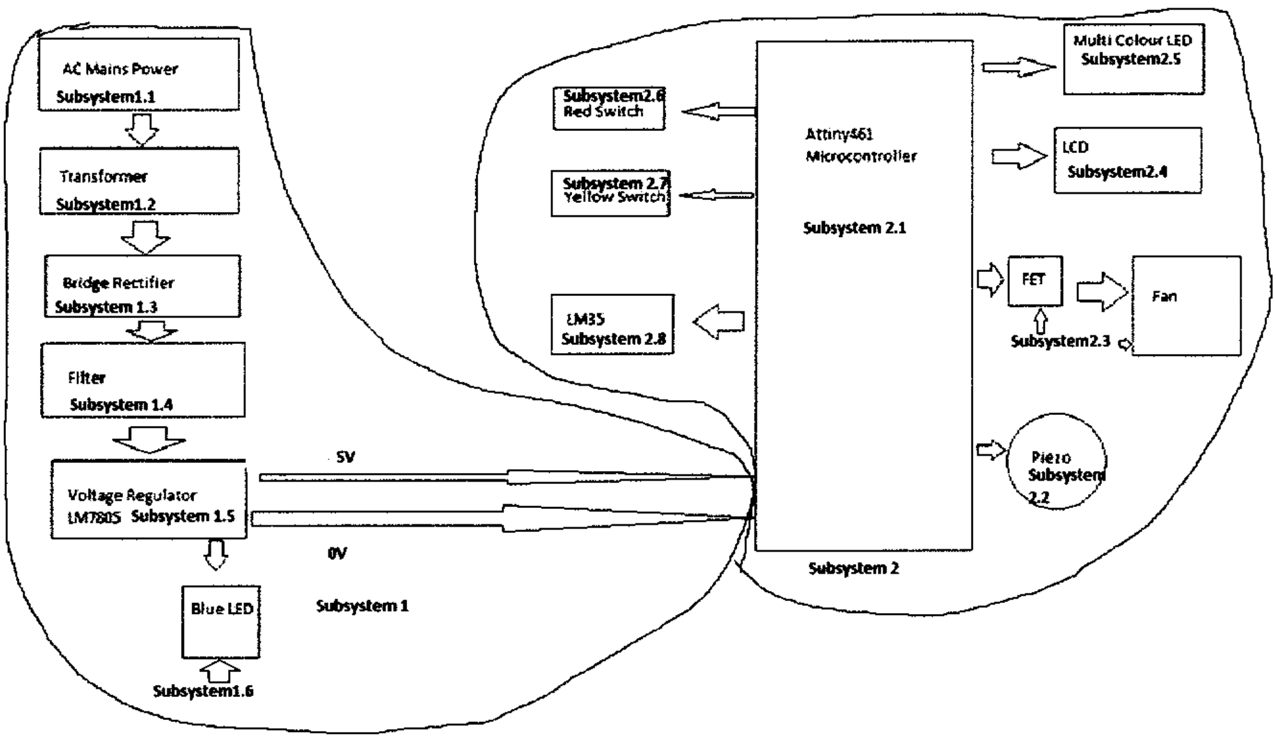
Below is a diagram of a computer's mother board with the subsystems that can be put on it, e.g. Graphics card (video card)



Subsystems are the smaller systems within the larger system, they all have their own individual roles which all are done to execute the role of the system, and they can be either part of the input, processing or outputs. For example in a computer there are major and minor subsystems such as a graphics card. It is a subsystem itself but within it there are smaller subsystems such as the graphics chip, the heat-sink and many more.



System Block diagram



This diagram above is the entire system. This shows all the subsystems that are within my system.

As you can see in my project there are 2 major subsystems, and within those major subsystems are smaller subsystems. The first major subsystem is the power supply unit, and the second major subsystem is the microcontroller. For this subsystem analysis I will be going in depth for only the power supply portion of my project.

The reason I chose to make a linear power supply over the switch mode power supply is due to the fact that the switch mode power supply is dangerous because it has a capacitor that still hold a lot of voltage even though the SMPS has been unplugged, this could result in a severe electrical shock, another reason I chose the linear power supply over the SMPS is because the construction and making of the SMPS is a lot more complicated as there are more components. Also if the SMPS malfunctioned it's basically impossible you fix, it is possible but it is a lot more complicated. The main reason I chose the linear power supply over the SMPS is because my attiny461 microcontroller only requires 5V Dc, so using a SMPS would be unnecessary due to there being more time and money needed to create a SMPS

Note: A microcontroller is a system by itself as it contains many subsystems inside of it such as a CPU and memory, etc.

Power Supply (Inputs/Processing/Outputs)

Inputs:

For the power supply, the only input is the AC mains. It is the main source of power for my system.

Processing:

The first part of the processing are of my system is the transformer, it supplies low voltage AC to my power supply.

The next part of the processing is within the bride rectifier. This is where the AC is converted to DC.

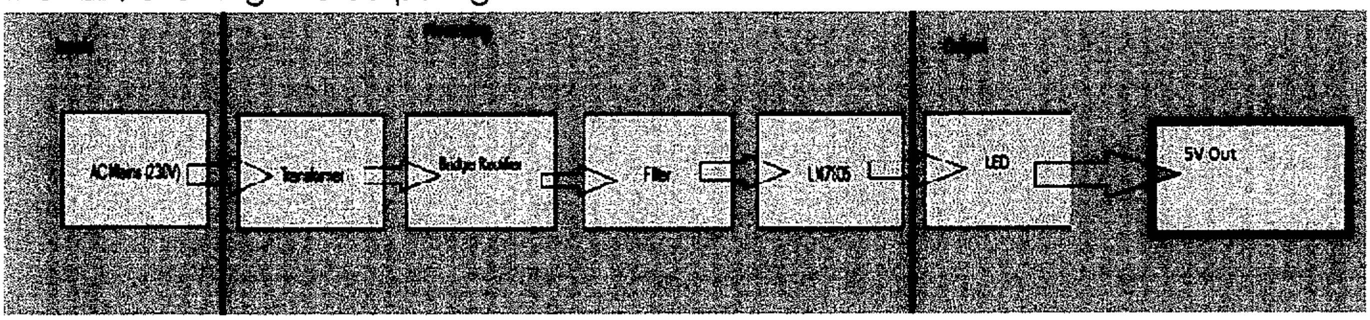
After the bridge rectifier is the filter. The filter keeps the DC constant so there are less spikes to avoid damaging the rest of the components.

Next the DC voltage is dropped to a constant fixed 5V, so that the power can then be used by the microcontroller in subsystem 2

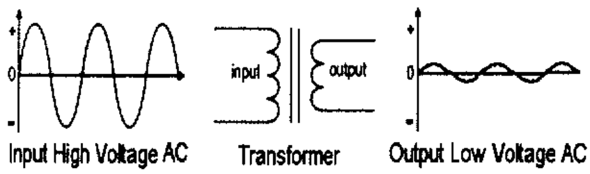
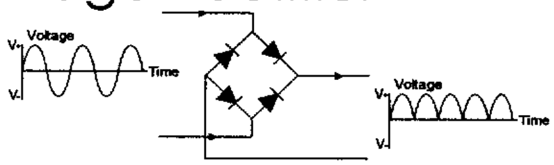
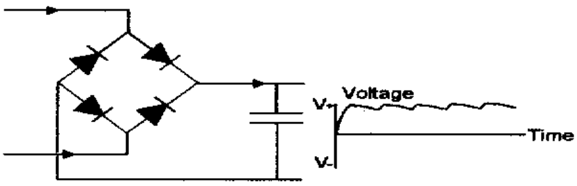
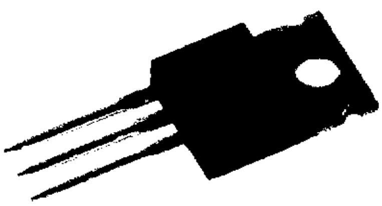
Outputs:

The main output on my board is the 5v DC, This supplies power to my attiny461 chip.

The LED on my power supply is an output, as some of the power from the PSU flows through the LED, allowing it to output light.



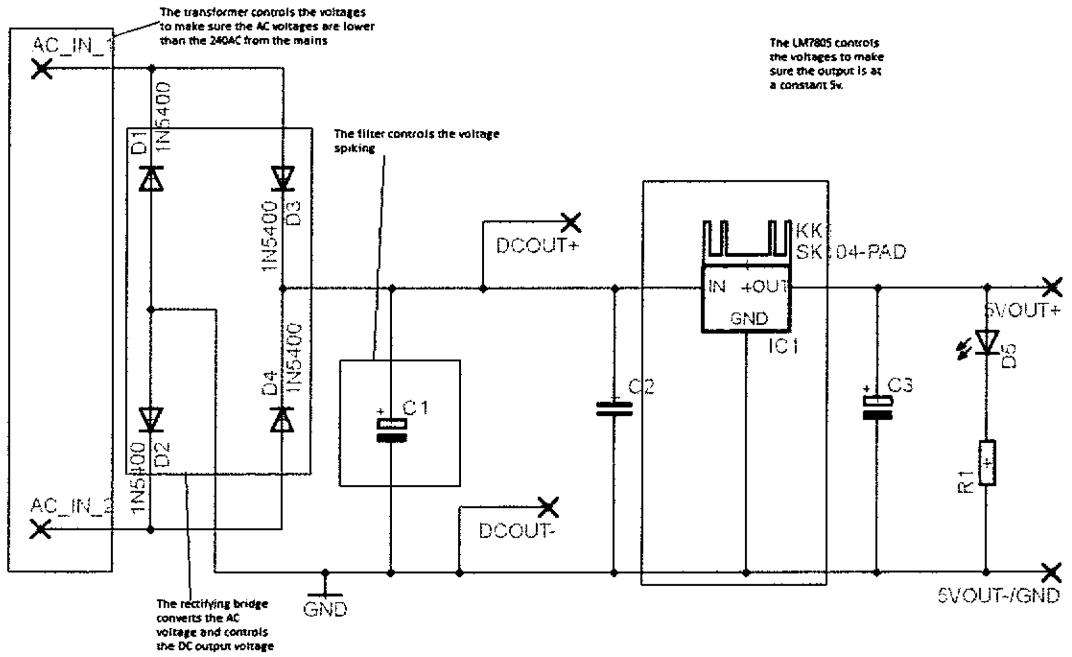
Subsystems within a Power Supply

Subsystem	Role
Transformer 	The role of the transformer is to convert the AC from the mains to a lower value. This is because 230V AC is not very safe and our circuit boards will not be able to handle such high voltages.
Bridge Rectifier 	Our circuit boards require DC voltages not AC, so the full wave rectifier is used to convert both half cycles of AC voltage into DC voltage. We don't use a half wave rectifier (1 diode) as it is inefficient thus the other half wave will go to waste.
Filter 	The filter consists of a 2200uF capacitor. This is to stop the DC from fluctuating or spiking. We want to stop the DC voltage from spiking as if it does keep spiking our other components will be damaged due to the inconsistent DC voltage. Note: there are different filters with more components, but for my project I only used a singed 2200uF capacitor.
Voltage Regulator (LM7805) 	Even after the DC voltage comes out of the filter it is still not smooth, there are still small fluctuations. The role of the 7805 is to make the DC voltage a constant 5V. The 7805 can only operate in conditions from 0 degrees Celsius to +120 degrees Celsius, so a heat sink is required to reduce the strain on the 7805, If the 7805 exceeds 150 degrees Celsius it will go into thermal shutdown.

Control and Feedback

Control:

Control is always evident within my power supply even without the presence of feedback. For example in the transformer the voltage is controlled to be at 13V. After the voltage is rectified the bridge rectifier, it also control the DC output voltages. The filter controls the voltage spiking so that the other components aren't harmed. The LM7805 controls the voltages to a constant 5v output so that the microcontroller can operate.



Feedback:

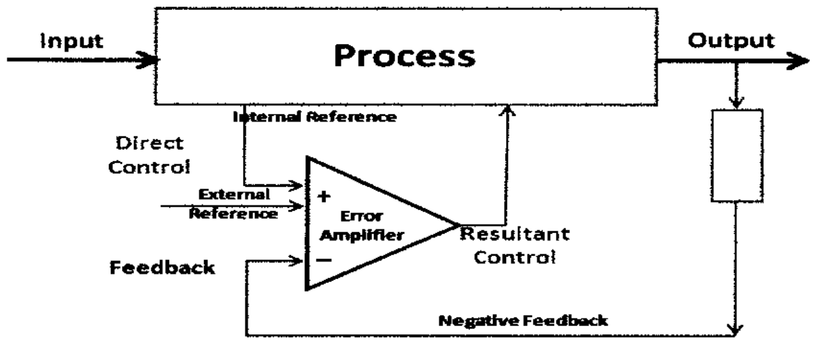
Feedback is used to control a certain aspect of a subsystem. For example in the mains there is a fuse. The fuse is an example of current limiting, if the current get too high the fuse will blow thus stopping all current to the board. Current limiting makes sure that the components that are connected to the mains won't get damaged if such high current were to actually occur.

In my power supply there is a constant 5V DC output this mean that there is voltage regulation within the LM7805. The regulator is a series pass transistor controlled by an op-amp and transistor. The op-amp is there to compare difference in the output voltage (V feedback from voltage divider) and the reference voltage (V ref from the zener diode) after this the op-amp increases or decreases the drive voltage that is going towards the series pass transistor to make sure the 2 input voltages are equal. If the input voltage is too high the LM7805 will start to heat up and thus will go into thermal shutdown.

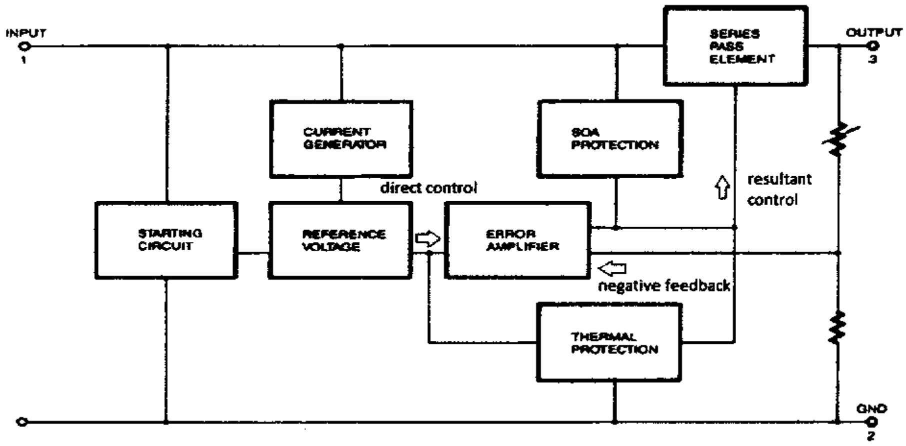
Thermal shutdown is also a control and feedback loop. When the temperature of the LM7805 goes over 150 degrees Celsius there will be a signal sent to the amplifier (feedback) and then the LM7805 will shut down as a result of this.

Reasons why the LM7805 will go into thermal shutdown – High voltages will cause it to heat up, there is heat from items like a heat gun, etc.

Process control with negative feedback loop:



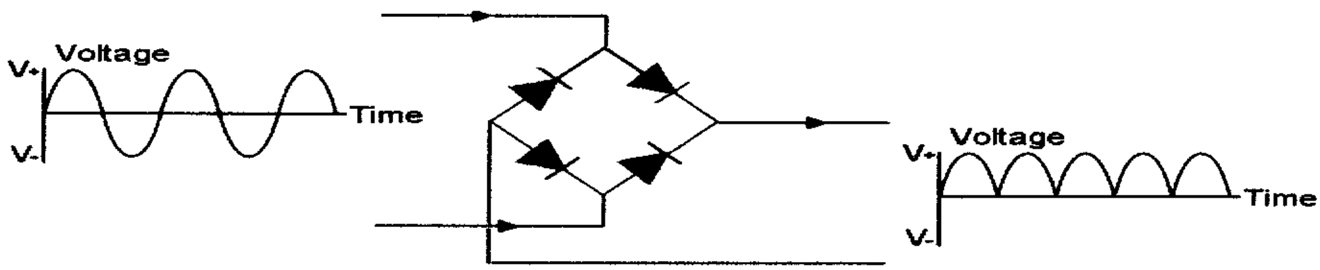
LM7805 internal block diagram:



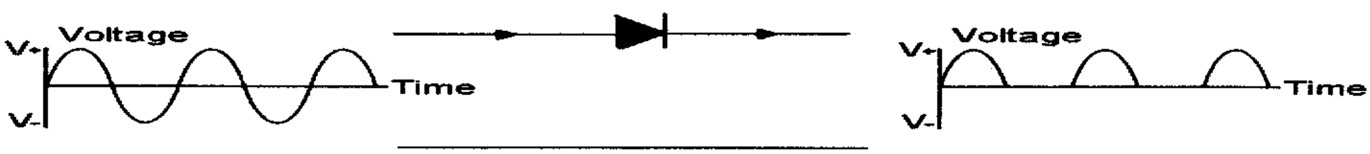
Advantages and Disadvantages of My Subsystems

Advantages:

Bridge Rectifier:



The bridge rectifier on my current power supply is a full wave rectifier this means it consists of 4 diodes, this mean that both half cycles of AC voltage are used meaning that it's near 100% efficient. So if there is a 150VA transformer I will be able to use nearly 150VA. It is also advantageous in the fact that the diodes are inexpensive and easy to remove meaning that it would cost very little money and time to replace.



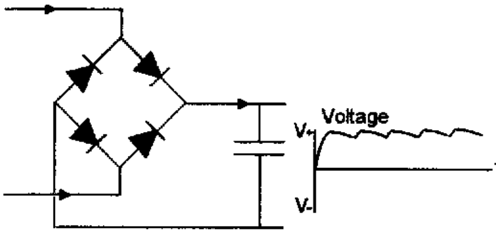
The 2nd diagram on this page is a half wave rectifier which mean that it only converts and uses half of the AC voltage. So with the same 150VA transformer we will only be able to use 75VA out of the full 100VA.

Voltage Regulator LM7805:

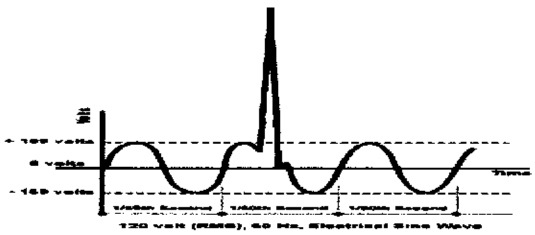
The LM7805 in my subsystem 1 is better for my project as it is smaller. This is because my board will have to fit into a small box. It also doesn't require other components to regulate the 5V so this means it is also a lot cheaper. Another benefit of the LM7805 is the thermal shutdown and current limiting features that are built into it. This will mean that the chip will shut down if there is too much input voltage and if it overloads it will shut-down once it hits 150 degrees Celsius. I chose the LM7805 over the lm2940T -5 because he requires less components to operate sin the lm2940 requires 2 extra capacitors to work, the LM7805 would be cheaper and more space efficient.

Filter:

Having a filter in my board is an advantage as it helps to reduce DC voltage spikes after the AC from the mains have been converted to DC by the Bridge rectifier. Voltage spikes are when the voltage fluctuates to make inconsistent voltages. The benefit of stopping the voltage spikes, is that it helps protect the components, as the fluctuating voltages can be potentially harmful to components such as the LM7805, or Subsystem 2 (page2).Since the circuit board can handle 5V DC this means if it fluctuates past 5V it may damage and blow one of the components.



The graph on this diagram shows how the capacitor keeps the voltage fluctuation to a minimum.



On this diagram the graph shows how voltage can fluctuate.

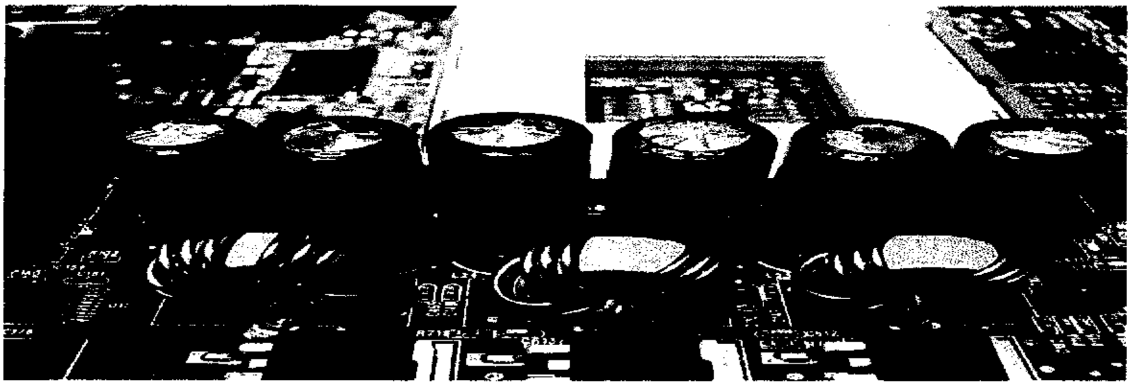
Disadvantages

Bridge Rectifier:

Currently on my board I am using the full wave rectifier, this means that there are 4 1N4007 diodes, when compared to a half wave rectifier which only uses 1. The result of using 4 diodes instead of one is a disadvantage as this takes up a lot more space on my PCB, also this means that the cost increases as you have to pay 4 times as much and the process of replacing the diode is they were to malfunction would take longer. Also the diodes produce heat which means that having a full wave rectifier will mean I will possibly have to use a fan too cool it.

Filter:

On my board I am using a 2200uF electrolytic polarized capacitor. This type of capacitor is usually the largest of its kind which means that it I have to create a lot of space so that it won't interfere with my other components (refer to the second image on page 7). Also since the capacitor is polarized this means that I have to be careful when I put it onto my board as if I put it in the wrong way the capacitor the top will burst, this is a disadvantage because if I or another student was not careful extra money would have to be spent on replacing the capacitor. The image below shows what happens if the capacitor is put in wrong.



LM7805:

The LM7805 needs a method to dissipate the heat it creates, so it requires a large heat-sink and fan to help dissipate the heat more effectively. Due to the heat-sink being quite large it would interfere with a lot of my components, this means that when planning the board layout for the PCB you will have to make sure the heat-sink will not interfere with other large components such as the 2200uF capacitor (Refer to Image below). Another disadvantage is that it is fixed at 5V that means it can only be used by board that can handle 5V DC max, E.g. it won't be able to power a 12V circuit board.

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Implications of Subsystems

A. Design:

Subsystems with the design section of my power supply are greatly beneficial as it allows me to make sure all the components have enough space between them. For example, during the design process I have to make sure I place the LM7805 and heat-sink in an area which is away from the large 2200uF capacitor as they would not fit onto the board if I place them close to each other. So basically the subsystems allow me to plan the area where each subsystem will be so I can maximize the space and make sure the PCB will fit into my project box.

B. Development:

The transformer on my board help lower the AC input that is given from the mains to a lower voltage, if the transformer was not present the rectifying bridge will most like malfunction due to the large amount of AC. Next the rectifying bridge with in my board rectifies the AC input voltages into DC output voltages. Without the DC voltages the filter will give off AC voltages which means that the LM7805 and microcontrollers will not function because they need DC voltages to operate. Next the Filter which consists of 1 2200uF electrolytic capacitor reduces the voltage spiking so that the LM7805 and microcontroller will not be harmed. Without this filter the voltages spikes my end up causing the microcontroller to malfunction as the maximum voltage the microcontroller can take is 5.5V, so it the voltages spike past 5.5V it will be unsafe to operate. After the voltage spiking is reduced by the filter the LM7805 stabilizes and regulates the voltage to a constant 5V this is because for my microcontroller the maximum voltage is 5.5V so 5V would be sufficient for the microcontroller. If the DC voltages were not constant and fixed the microcontroller with be damaged due to taking in high voltages that are not within the requirement of the microcontroller.

C. Maintenance:

Maintenance is made simple by having subsystems. Since there are multiple subsystems it will be easy for me to identify any problems within the power supply. Having the subsystems separate from each other means that if one of the subsystems were to malfunction then it would be easy to locate the broken component and replace it with another, this also means that it is cheaper as the whole system does not have to be replaced. This is also why I picked the linear power supply over the SMPS (Switch Mode Power Supply). The linear power supply with the LM7805 voltage regulator is easy to repair and maintain due to it having multiple distinct subsystems, thus I'll be able to point where the malfunction occurs, whereas for a SMPS it is practically unrepairable once it is broken.