

# **Kinkajou Power Supply**

Team 4

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# 1 Executive Summary

World Education and Design that Matters are both non-profit organizations that help improve the quality of living in developing countries. Our project will be focusing on a design both organizations have been working on to improve the literacy rate in Mali. About 62% of the people are illiterate in Mali, which is about 7 million people ([www.designthatmatters.org](http://www.designthatmatters.org)). The problem is not because the people in Mali don't want to be educated. The problem is that they don't have the resources to educate the adults and children.

World Education and Design that Matters collaborated on the idea of the Kinkajou Projector, which is a microfilm projector that projects images in the poorly lighted classrooms. The projector can carry up to 20,000 pages of materials that are stored on a cassette. Both organizations hope that the Kinkajou Projector will help decrease the illiteracy rate and help educate the developing countries. This projector will significantly impact the quality of living for developing countries.

Our design will be focusing on the power supply of the Kinkajou Projector. Our goal is to design an efficient power supply that will be powered by a 12V rechargeable battery. Our final prototype of the power supply will roughly cost \$15. However, the cost decreases to \$5 when producing the power supply in bulks of a 100 units. The low cost of our product should create a significant market for our power supply in the future.

## 2 Introduction

### 2.1 Problem Statement

In the beginning of this project, we were given the following problem statement:

“You are to design the power supply for the Kinkajou Projector. The power supply must provide a constant current to the 5W white LED inside the projector, as well as run a small DC cooling fan. The input to the power supply will be a nominal 12 Volts from either a typical automotive battery or a 12 Volt battery pack. The circuit must be as efficient as possible to extend battery life. In addition, the circuit should indicate when battery voltage is low and shut itself down if the voltage drops below a certain level. The circuit must be integrated into the Kinkajou Projector and not add more than 10% to the production cost. Prototype cost should not exceed \$50.”

(<http://ece.wpi.edu/~vaz/courses/ee2799/b03/Labs/kinkajou.htm>)

### 2.2 Planned Approach

The problem statement above requires that we design a power supply that meets the following criteria:

- Drive the 5W white LED with constant current and drive the small DC cooling fan with constant voltage
- Powered by a 12V rechargeable battery
- Indicate when the battery voltage is low with an LED
- Shuts off automatically when the voltage has dropped below a certain level.
- Cost under \$5 or less than 10% of the total production cost.

Our market research, presented in section 3 of this report, revealed that there is a great interest in designing our power supply to be able to operate in all kinds of temperature and weather conditions. Since our primary market is in Mali, we need to develop a power supply to withstand extremely hot climate. Our initial design plan varied greatly from the beginning of this project to the final design. The reasons for the design change will be present in the sections to follow. The main focus of our plan was to keep it simple, in order to keep cost low.

### **3 Product Specification Generation**

#### **3.1 Market Research**

The market for the Kinkajou Projector will be primarily focused in Mali. The way we conducted our market research was browsing the World Wide Web. In particular, we browsed through the websites of MIT and Design that Matters to obtain the majority of the background information that they had already researched. Design that Matters and MIT worked together as a team to develop the first prototype of the Kinkajou Projector. The information and resources that the team gathered is open to the public on the World Wide Web.

The Kinkajou Projector will aid schools and businesses in developing countries that don't have libraries. The projector will also be able to provide libraries because it can be used to store a reference library up to 20,000 pages of material. Microfilms are even used in the library of WPI. The projectors that schools are currently using are so expensive. The beauty of the Kinkajou Projector is that it will be affordable to all people. The demand for this product will be tremendous because the projector will be sold for an affordable price. As you can see, the Kinkajou Projector can be of use for schools and businesses all over the world.

In Africa alone, over 315 million people don't know how to read. Over 62% of the population in Mali is illiterate ([www.designthatmatters.org](http://www.designthatmatters.org)). The Kinkajou Projector will help project teaching materials in the dark classrooms for the adults and children. MIT succeeded in developing the first prototype. Figure 1 shows the Kinkajou Beta prototype MIT had developed as their final product. The Kinkajou projector is a battery-driven projector that projects an image so bright that the adults and the children will all be able to read in the dark classrooms. The rechargeable batteries will be recharged either by 110/220V, solar power, or human bicycle pedal power. Design that Matters has a targeted value of \$50 for the total microfilm projector. They hope the cost of the power supply to be 10% of the total production cost.

### **Figure 1: Kinkajou Projector Prototype**

We have concluded that Mali will be the primary market for the Kinkajou Projector. The purpose of this projector is to help educate the adults and children in Mali. Design that Matters and World Education have developed the Kinkajou Projector to decrease illiteracy in Mali. The Kinkajou Projector fills a need for students who are faced with limitation such as lack of AC electricity, high textbook costs, and poor access to educational materials. In the future, this projector will be a market for developing countries all around the world.

The results of our market research have laid down a necessary building block for beginning our project. We found that our market is primarily Mali, however the market is expected to expand to other developing countries. Our market research will provide us with the information to develop a list of customer requirements.

### **3.2 Customer Requirements**

According to the results of our market research and common sense, we have developed a list of the following customer requirements:

- Durability
- Affordable
- High Efficiency & Low power consumption
- Small size & Lightweight
- Low maintenance
- Stable
- User friendly

### **3.3 Initial Product Specifications**

After developing our customer requirements for the power supply, we used these requirements to create a list of product specifications.

- The power supply should have an On/Off Switch control.
- The power supply should have an automatic shutoff circuit.
- The power supply should have a strong protective casing.
- The power supply should have a low battery status indication LED.
- The power supply should provide a constant current of 700mA for the 5W white LED.
- The power supply should provide a constant voltage of 12V to the DC cooling fan.
- The power supply should have four Molex connectors: 2 input wires to power supply and 2 output wires to projector.
- The power supply should cost no more that \$5 or 10% of total production cost.
- The power supply should be able to withstand voltage spikes due to the 12V battery.
- The power supply should be small in size and lightweight.
- The power supply should be able to operate in a wide range of temperature.

### 3.4 Final Product Specifications

Our final product specifications still meet all the initial product requirements. However, some of our specifications that were vague have been specified with numbers during the design process. The most significant changes in our design are contained within the decision circuit. We decided to indicate low battery at 12.24V, when the battery voltage has reached 50% state of discharge. We also decided the automatic shutoff to be turn on at 12.06V, when the battery voltage has reached 25% state of discharge.

The second major change was that the fan needed to be run at a constant voltage of 12V. Originally, we had the small DC cooling fan connected straight to the 12V battery. The problem with this approach was that the battery voltage fluctuates around 14.1V to 10.5V. The fan would not be able to withstand the voltage spikes of the battery. Our research shows that many DC cooling fans can be driven by a voltage range of 8V to 13.8V ([www.digi-key.com](http://www.digi-key.com)). So, we decided to connect the fan after our voltage regulator module, which provides a constant 9V. Currently, the fan is being driven at 6V DC, thus we believe 9V will be plenty for the fan.

## **4 Development Product Timeline**

In order to stay on schedule throughout the design process, we developed a Gantt Chart. Our Gantt Chart shows all the tasks include a researching, designing, experimenting, building and troubleshooting, testing and verifying, and final report/presentation. Each task will list who is responsible for completing the task, as well as who is involved. We have assigned tentative dates as when we want each task to be completed. However, we have also included a contingency plan for each of the tasks, just in case we fall off-schedule.

We have included two Gantt charts to outline tasks, deadlines, and milestones in appendix A and B. The first chart is top level Gantt Chart of researching, designing, experimenting, building and troubleshooting, testing and verifying, and final report/presentation. The second chart provides all the task specifics for each of the top level tasks. All the responsibilities were equally distributed among the team. Each of us worked on individual designs, but as a group we would develop one design for each module. We worked primarily together as a group on each of the tasks.

## 5 Design Approach

### 5.1 Design Options

We have divided our design in 2 main parts: Decision Circuit and Current & Voltage Regulator. We had many design options to choose from when designing each module. Most of our designs are fairly simply using basic knowledge of transistors, opamps, resistors and capacitors. We performed 2 different value analysis matrices, which evaluates the several different design alternatives for each module.

### 5.2 Value Criteria of Design Options

The different components of the circuit will have to be weighed in order of importance in order to keep our circuit efficient and small. We designed a value matrix in order to show the importance of these options. We will be using quality, convenience, and price as our criteria.

Decision Circuit:

- Cost
- Size
- Complexity
- Power consumption

Current & Voltage Regulator:

- Cost
- Size
- Complexity
- Power consumption

### 5.3 Metrics for Value Analysis

For our matrices, cost is the most important option, then quality and then convenience. All the weighting factors are ranked from 1 to 4.

### 5.4 Summary of Design Approaches

After the brainstorming process, we got several different choices for each category:

Decision Circuit:

- Zener Diodes
- AND or NOR Gates

- Opamps

Current & Voltage Regulator:

- BJT
- Darlington Pairs
- Switching Voltage Regulator

## 5.5 Specific Module Design Options

### 5.5.1 Current & Voltage Regulator Value Analysis

The voltage regulator must be able to be powered by either a standard 12V car battery or the battery charger. The regulator needs to be able to withstand the voltage spikes of the 12V car battery. We need the voltage regulator to be able to accept of an input voltage range of 10.5V to 14.1V and be able to produce a constant voltage for the DC cooling fan. The current regulator must be able to provide a constant current 700mA of to drive the LED in the projector.

There are several different designs for a current supply that we came up with that have varying degrees of efficiency and complexity. Our first design is the simplest, using a BJT driven by a voltage divider to provide a constant current source. Our next design replaces the BJT with a Darlington Pair to reduce the current necessary in the voltage divider, increasing the circuit's efficiency. The final design uses a switching circuit to reduce the input voltage from the battery to 9 volts before sending it to the BJT current source.

Since these designs are all built from components, the price will be roughly equivalent to the complexity, and can therefore be ignored as a separate factor. The durability of the circuit will also be inversely related to the complexity, with more complex circuits failing more often. The quality of this circuit will be mainly based on the circuit's efficiency, with a more efficient circuit being higher quality, therefore quality can also be ignored for this analysis. As a final measure we used the efficiency minus the complexity, as shown in the following table. The efficiency shown is the minimum theoretical efficiency and the complexity is given according to the following scale:

Complexity of the circuit	
Simple	4
Moderate	2
Complex	1



Moderate 2  
 Complex 1

We ranked cost at 4 because it's the most important, then efficiency at 3 and complexity at 2.

		Value Analysis						
		Market	Zener Diodes		AND and OR Gates		OpAmps	
Quality		Value point	Value point	Total	Value point	Total	Value point	Total
Cost		4	2	8	3	12	3	12
Efficient		3	1	3	1	3	3	9
Complexity		2	3	6	3	6	2	4
<b>Value: (Efficient*Complexity)/Cost</b>				4		6		27

Figure 3: Value Decision Circuit

## 5.6 Metrics for Value Analysis

In order for our power supply to have a successful market, we need to meet all the customer requirements. We need to design a power supply that will meet all the requirements that the customers ask for. From brainstorming we developed a list of customer criteria essential for the power supply.

### Customer Criteria

- Quality
  - Efficient
    - 90%+ 5
    - 89→80% 4
    - 79→70% 3
    - 69→60% 2
    - 59→50% 1
  - Complexity of the circuit
    - Simple 3
    - Moderate 2
    - Complex 1
  - Warranty
    - 5 years or more 3
    - 2 yrs → 4 yrs 2
    - 1 year 1
- Convenience
  - Size
    - Smaller than Hand 3
    - Handheld 2
    - Larger than Handheld 1

Weight	
Less than 1lb	3
2lbs→9lbs	2
greater than 10lbs	1

- Price

Price of Power Supply	
Less than \$50	3
\$51→\$100	2
greater than \$100	1

## 5.7 Competitors

If you browse the World Wide Web for power supplies, you will encounter many power supply manufacturers out in the market. For the purpose of comparing the competitors to our power supply, we decided to choose the following three major power supply manufacturers: Acopian, Sola, Vicor and Meanwell. The table seen below summarizes one power supply from each manufacturers that closest meets our power supply. Our competitor value analysis can be seen in Appendix C.

Sola/Hevi-Duty offers products are used for industrial power quality problems such as blackouts, voltage surges. Sola/Hevi-Duty offers a wide range of quality products, including UPS, power conditioners, voltage regulators, shielded transformers, TVSS and power supplies. As you can see, Sola has developed a large market in power supplies. Vicor is an international company that designs, manufactures and markets power supply and other power components. Meanwell is also an international company with businesses set up in China, Taiwan and USA. Since Vicor and Meanwell are both international companies, they have developed a very large markets ranging all over the world.

<b>Description</b>	<b>Sola</b>	<b>Vicor</b>	<b>Meanwell</b>	<b>Acopian</b>
<i>Price</i>	\$166.00	\$249.00	\$7.10	\$129
<i>Switching Power Supply</i>	yes	Yes	yes	yes
<i>Temperature Range</i>	-25C → 65C	-25C → 71C	-25C→105C	-20C→ 71C
<i>Weight</i>	.85lbs	9.25lbs	Less than 1lbs	14 oz.
<i>Size</i>	4.72x2.55x1.29 in	3.4 x 6.0 x 12 in	.89 x .39 x .33 in	1.4 x 2.5 x 3.5 in
<i>Efficiency</i>	75%	50%	60%	70%
<i>Warranty</i>	5 yrs	1 yr	1 yr	5 yrs

**Table 1: Competitors**

## 5.8 Capabilities

Obviously, we will be creating a power supply that will meet all the customer criteria. Realistically we need to decide which requirements can we meet and which will be impossible to meet or maybe we can meet all the requirements. Our ideal power supply will meet all the requirements that we have specified.

The advantages of our power supply are that it will be low cost as well as efficient and durable. The fact that it is essential to design a power supply that has to be low cost can be a disadvantage to us. We need to take into consideration how cost effects the efficiency and durability of a circuit. In our minds, we think the more money we pay, the more quality we are getting. How much quality and efficiency will our low cost power supply actually have. The value analysis spreadsheet is attached to the appendix which compares our power supply to the other four power supplies.

## 6 Module Descriptions

This section will describe how each module will be developed, debugged and tested. We will provide a top-level block diagram to show each of the modules in our power supply. Each module will have a detailed I/O specification for all inputs and outputs of voltages, current, frequencies. We will provide detailed calculations, as well as a simulation for each module to verify the input/output behavior. Finally, we will tie all the modules together and test to verify compliance with our specifications.

Our general system block diagram consists of an input, 3 major modules for the power supply and an output which can be seen in Figure 1. The 12V battery will be the input of our power supply. We decided to control our power supply with an on/off switch for the purpose of safety. The decision circuit, low battery circuit and current source are the 3 major modules for our power supply. Then we have our power supply output 700mA for the 5W LED and the 12V DC for the cooling fan.

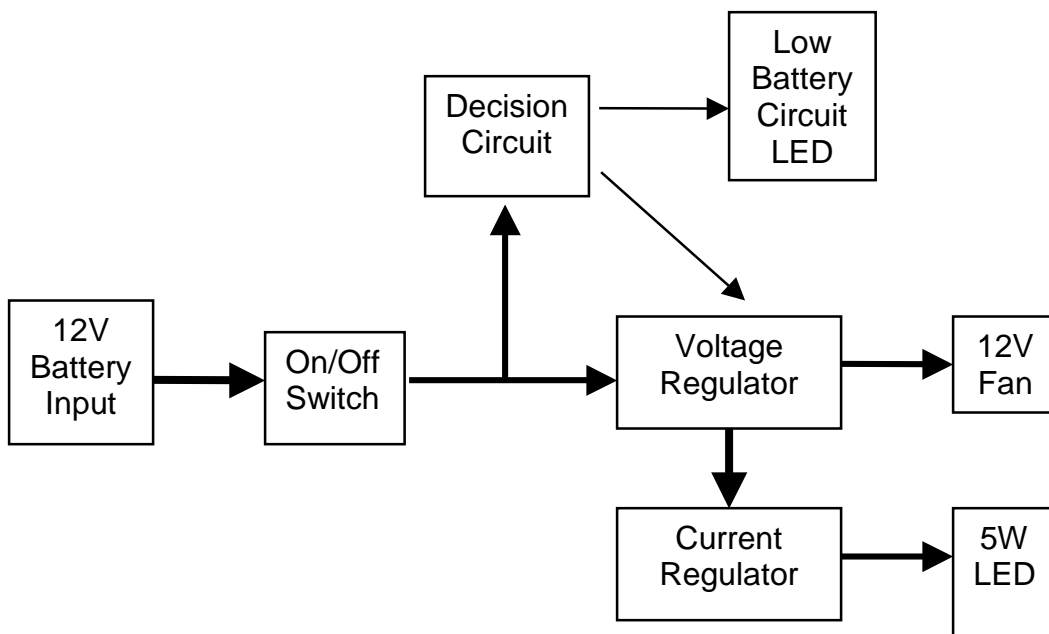


Figure 4: System Block Diagram

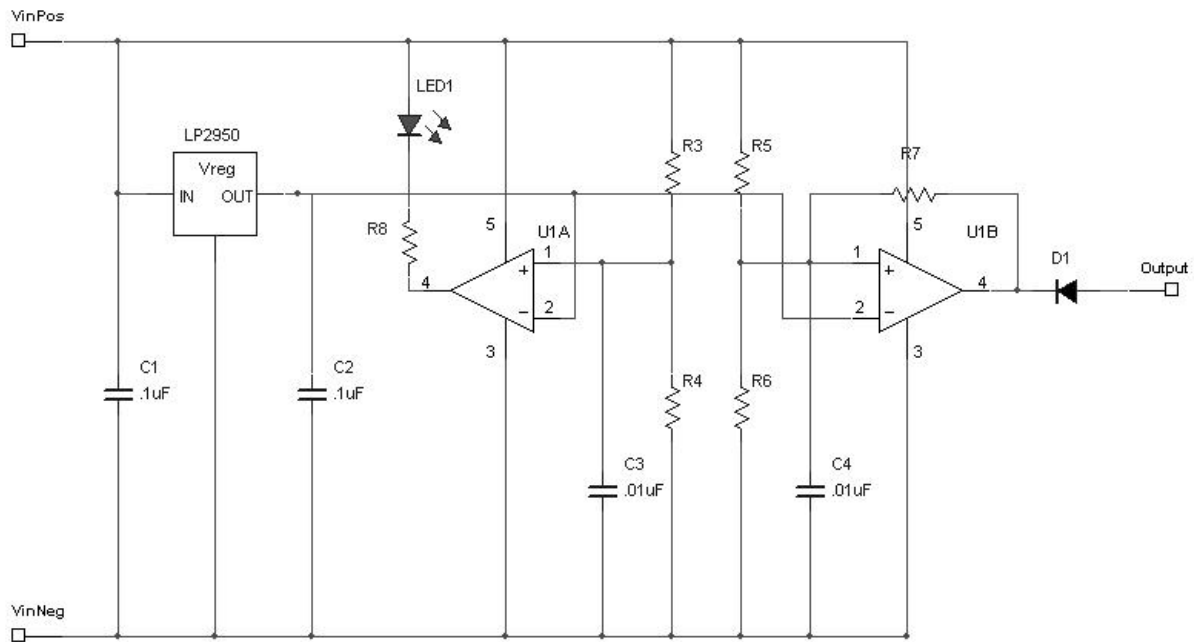
### 6.1 Module Descriptions

#### 6.1.1 Decision Circuit

We started by looking for similar low battery circuits on the World Wide Web. Luckily, we encountered a low battery warning circuit for a 12V battery, “N5ESE's Low Battery Warning Gizmo.” We had to make slight modifications to this circuit by replacing

resistor values and the MAX931 IC. We felt that the MAX931 IC chip was not worth the \$2.50, when it is fairly simple to duplicate using an opamp.

The major addition to the low battery circuit was that we also needed to shutoff the power supply when the battery voltage was too low. We used the low battery design as a reference for the shutoff addition. We combined the low battery circuit and the shutoff circuit as one design. We used the 5V voltage regulator as our voltage reference for the two opamps. We used the information of 12.24V as low battery voltage reference and 12.06V as shutoff voltage reference. We want the opamp to output high when the voltage at the positive terminal is less than or equal to 5V. The way we calculated our resistor values was by the simple voltage divider approach. We chose a small current in the voltage divider so we don't dissipate much power. We assumed the current in the voltage divider was 1mA. The actual resistor values we calculated are as seen in Figure 4.



**Figure 5: Decision Circuit**

## 6.1.2 Voltage Regulator & Current Regulator

The Voltage Regulator and the Current Regulator have remained the same from our first design. We have actually combined the voltage regulator and current regulator as one design as seen in Figure 5. We haven't encountered any problems with either of the two modules thus far. We will be using a Buck Voltage Regulator to provide a constant voltage of 9V.

We have also chosen the LM2675 IC as our switching regulator. The input of the LM2675 IC can handle an unregulated DC input of between 11 and 40 volts without any problems. The IC will then provide a regulated output of 9 volts to power the DC cooling fan. We found that there is no problem with providing the fan with a constant voltage of 9V, even though the fan is rated at 12V DC. Currently, the fan is being driven at a constant voltage of 6V, so 9V is more than enough.

The Current Regulator consists of all the components after the Buck Voltage Regulator as seen in Figure 5. Our final design for the current regulator consists of a voltage divider followed by a Darlington pair. Both the voltage divider and Darlington pair will provide a constant current of 700mA for the 5W LED. We tied the feedback pin of the LM2675 IC before the R3 resistor to verify the IC is providing a constant current of 700mA. Our design for the voltage and current regulator are complete and ready to build on breadboard.

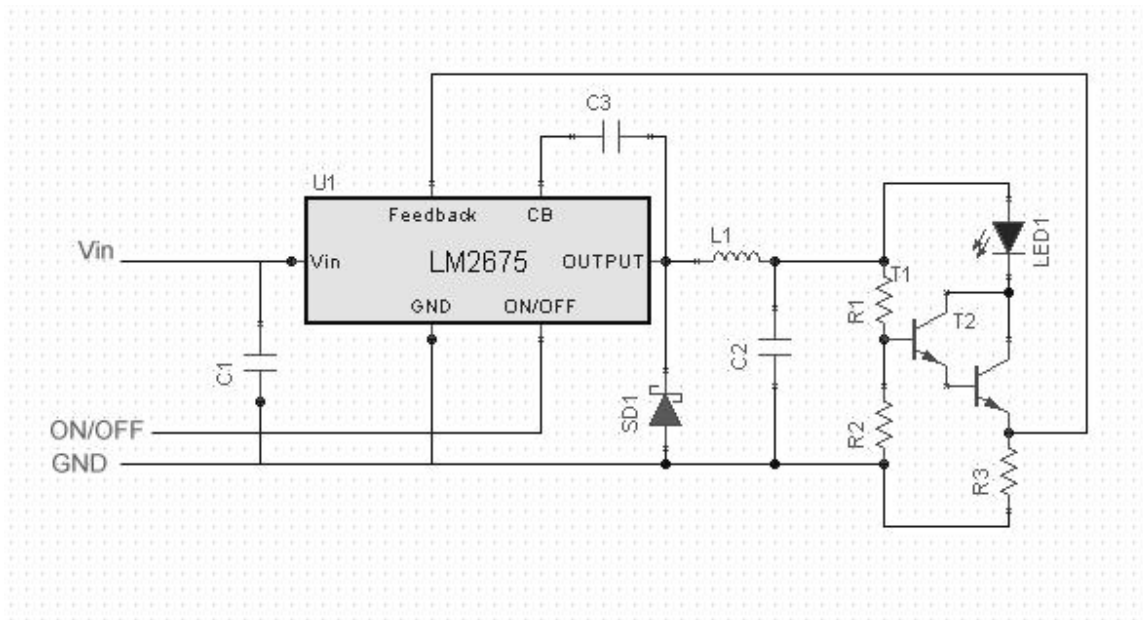


Figure 6: Voltage and Current Regulator Schematic

## 6.2 System Integration

Currently, we have completed the design phase of the project. We are now working on simulating each module to verify the output meets our specifications. It is important to test each module separately, in order to pinpoint a problem in the design.

Since we are not using a microcontroller PIC for our power supply, we only are concerned about hardware integration. We plan on using module design to integrate three distinct components for our power supply. We have decided to connect the decision circuit to the on/off switch of the LM2457. The “Circuit On/Off” will be connected to the control pin on the Buck Voltage regulator which will essentially turn the power supply on and off. After the Buck Voltage regulator, we have a Darlington pair to provide the constant current for the 5W LED.

Originally, we were going to connect the 12V battery directly to the DC cooling fan. However, we had to take into considerations the voltage spikes as a result of the 12V battery, thus we will connect the DC cooling fan after the Buck Voltage regulator. Currently, the DC cooling fan is run off of 6V DC, so we decided that 9V DC regulated would be suitable for the fan. Since the 9V is regulated, the DC fan will be protected from any voltage spikes from the 12V battery.

## 7 System Testing

We began building our prototype modules on two different breadboards, one for the decision circuit and the other for the current & voltage regulator. Once we finished building each of the modules, we began testing each circuit individually. Our general procedure was to test each module separately, in order to make the debugging process less complicating. Once each of the modules were functioning correctly, we would test the system as a whole.

### 7.1.1 Decision Circuit

The Decision Circuit had two three different states that we needed to verify: “Good Battery,” low battery and shutoff battery. The state “Good Battery” means when the voltage in the battery is 12.2V or higher, low battery is when the voltage is between 12.2V-12V and shutoff battery is when the voltage is 12V or lower. We used the power supply to provide different voltages to verify each of the three states for the battery.

During the testing process for the Decision Circuit, we had encountered some minor problems. The problems were very minor, so we were able to resolve them by slightly changing our original design. Finally our Decision Circuit was properly functionally each of the three battery states.

### 7.1.2 Current & Voltage Regulator

The Current & Voltage Regulator testing was the most different part of the power supply. We built the Current & Voltage Regulator module on a lower scale in comparison to the 5W LED. Instead of using the 5W LED, we used a white LED that was rated at 3.3V and 20mA. We began testing on a lower scale, just to verify the LM2675 switching regulator was functioning correctly.

Once our Current & Voltage Regulator circuit was working on the lower scale properly, we began testing the circuit with a 10 ohm 5W resistor, which was a substitute for the 5W white LED. When we added the 5W resistor in our circuit, the LM2675 seemed to be working properly. We measured a current of 630mA through the 5W resistor. When we applied a voltage of 12V or lower, the Current & Voltage Regulator circuit would turn off. When we applied a voltage of 12V or higher, the circuit would turn on and provide a constant current of 640mA. We never want the current to reach higher than 700mA because that will hurt the 5W white LED, so we designed our circuit to provide a little less than 700mA..

### 7.1.3 Final System Testing

The final system testing is the last phase of the testing process. Once we finished testing and debugging each of the modules separately, we combined the two circuits to make our power supply. We tested our power supply using the 10 ohm 5W resistor in place of the 5W white LED. We noticed that we needed to add a heatsink to protect our Darlington pair because they were getting warm. The final part of the testing phase was actually testing the efficiency of our power supply by measuring the power in and the power out through the resistor load and the small 12V DC fan. We calculated our power supply to be 66% efficient. In the end, we were very pleased with the efficiency of our power supply.

## 8 Product Results

### 8.0 Product Results

The power supply created within the last seven weeks by our team is actually very useful for the problem at hand. We created a fairly efficient supply, much more efficient than if the projector was directly connected to the battery, and we learned more than we could have ever imagined. Our product is low priced, effective, and sized perfectly for its application. Appendix D shows a graph which shows the return on investment for a number of years. It is estimated to have a break-even point at 1.6 years, but that is under the assumption of 500 sales a year. This model uses a linear assumption for sales, and is slightly inaccurate since one can not predict the future. It should be noted that a target goal of sales should be number of units, not number of years.

### 8.1 Standard Cost

The standard cost to produce our Kinkajou Power Supply is six dollars (\$6). This value includes parts, labor, and overhead for the project. Five dollars goes directly to supplies, while one dollar per unit pays for the overhead of the product. The five dollar (\$5) parts figure comes from a one-hundred unit production. If production numbers go up to one-thousand, then manufacturing costs go down by fifty cents to a dollar.

Since most of the design is finished for this product, there really is no need to pay any other engineers to work on this product. However, there is a need for patent costs, lawyer fees, and other aspects to protect Design that Matters legally. Since Design that Matters has a law firm willing to do this sort of work for them *pro bono*, these costs drop dramatically. The estimated figure before our team knew about the *pro bono* work was thirteen-thousand dollars (\$13,000). Now this number can drop to right around three-thousand dollars (\$3,000). Three thousand dollars split between 800 units ends up being \$3.75. Added together with the cost of producing the power supply, the breakeven point can now happen still at 1.6 years, but the entire projector costs eleven dollars (\$11) less than it did with lawyer fees.

## 8.2 Product Functionality

Our product supplies a constant current of 670mA to the main LED, during low battery states, supplies 20mA to the low battery detector LED, and supplies a constant voltage of 9.7 volts to the main LED cooling fan. This is almost exactly what we as a group wanted to accomplish.

Knowing these numbers, one would wonder at how efficient our circuit actually is. Our circuit has an efficiency of 68%, which would seem somewhat low. However if this LED would be hooked up to the battery through a linear regulator, the efficiency would be just over 50%, at 53%. Our power supply gives us a 15% raise in efficiency, which is a phenomenal increase by adding a circuit between the battery and the projector. Overall this is a great design and although it works, it can be improved upon.

## 8 Next Steps and Recommendations

Looking ahead, there is a great deal that we can do to improve our power supply. During our testing phase, we noticed that some of our components would warm up considerably. The reason why some of our components were getting warm was because the circuit was operating close to the components maximum capacity. We recommend replacing the following components in our power supply: the heatsink, BJT transistor, feedback resistor and inductor.

The Darlington Pair would still warm up considerably even though we added a small 2W heatsink on the BJT transistor. We recommend that next time use a bigger heatsink or replace our transistor with one that is able to handle more current. The feedback resistor that we are currently using is a 1W 1.8 ohm resistor. This resistor seems to be getting considerably warm when we run the power supply for more than 10 minutes. We recommend replacing the feedback resistor that is rated at higher wattage than 1W. The resistor used in our prototype is also rated at a tolerance of 5%, but when the design is being mass produced, a resistor with a lower tolerance should be used to minimize variations between power supplies. Lastly, our inductor seems to be getting warm due to the high impedance inside the inductor. We recommend choosing an inductor that has low impedance, preferably less than .5 ohms inside.

After the recommendations are taking into consideration, we want to move our circuitry from the protoboard to a printed circuit board. This is the final step for the development of our product. The final PC board will then be enclosed in a protective casing to protect the power supply from high temperatures and user interface.

**Appendix A**  
**Top-Level Gantt Chart**

Task Name	People Responsible	27-Oct-03							3-Nov-03							10-Nov-03							17-Nov-03							24-Nov-03							1-Dec-03							8-Dec-03							15-Dec-03																				
Research	All	[Shaded]																																																																					
Design	All	[Shaded]																																																																					
Building & Troubleshooting	All	[Shaded]																																																																					
Test & Verification	All	[Shaded]																																																																					
Final Report & Presentation	All	[Shaded]																																																																					

**Appendix B**  
**Task-Specific Gantt Chart**

ID	Task Name	People Responsible	27-Oct-03	3-Nov-03	10-Nov-03	17-Nov-03	24-Nov-03	1-Dec-03	8-Dec-03	15-Dec-03
<b>1 Research</b>		All	█	█	█	█	█			
	Research Data Specifications	Prity								
	Research Power Supplies	Sean								
	Research Switching Voltage Regulators	Matt	█	█	█	█	█			
<b>2 Design</b>		All					█	█		
	Design Current Source	Matt								
	Design Decision Circuit	Prity & Sean								
	Design Fan Driver	All								
<b>3 Building &amp; Troubleshooting</b>		All					█	█	█	
	Build on Multisim	Matt & Sean								
	Order Parts	Prity								
	Build on Circuitboard	Prity & Matt								
<b>4 Test &amp; Verification</b>		All						█	█	█
	Test & Verify Current Source	Sean & Matt								
	Test & Verify Decision Circuit	Prity & Sean								
	Test & Verify Final Prototype	All								
<b>5 Preparing Final Report and Presentation</b>		All								
	Writing Final Report	Prity & Sean								
	Writing Final Presentation	Matt								
	Present Final Project	All								

**Appendix C**  
**Competitors Value Analysis**

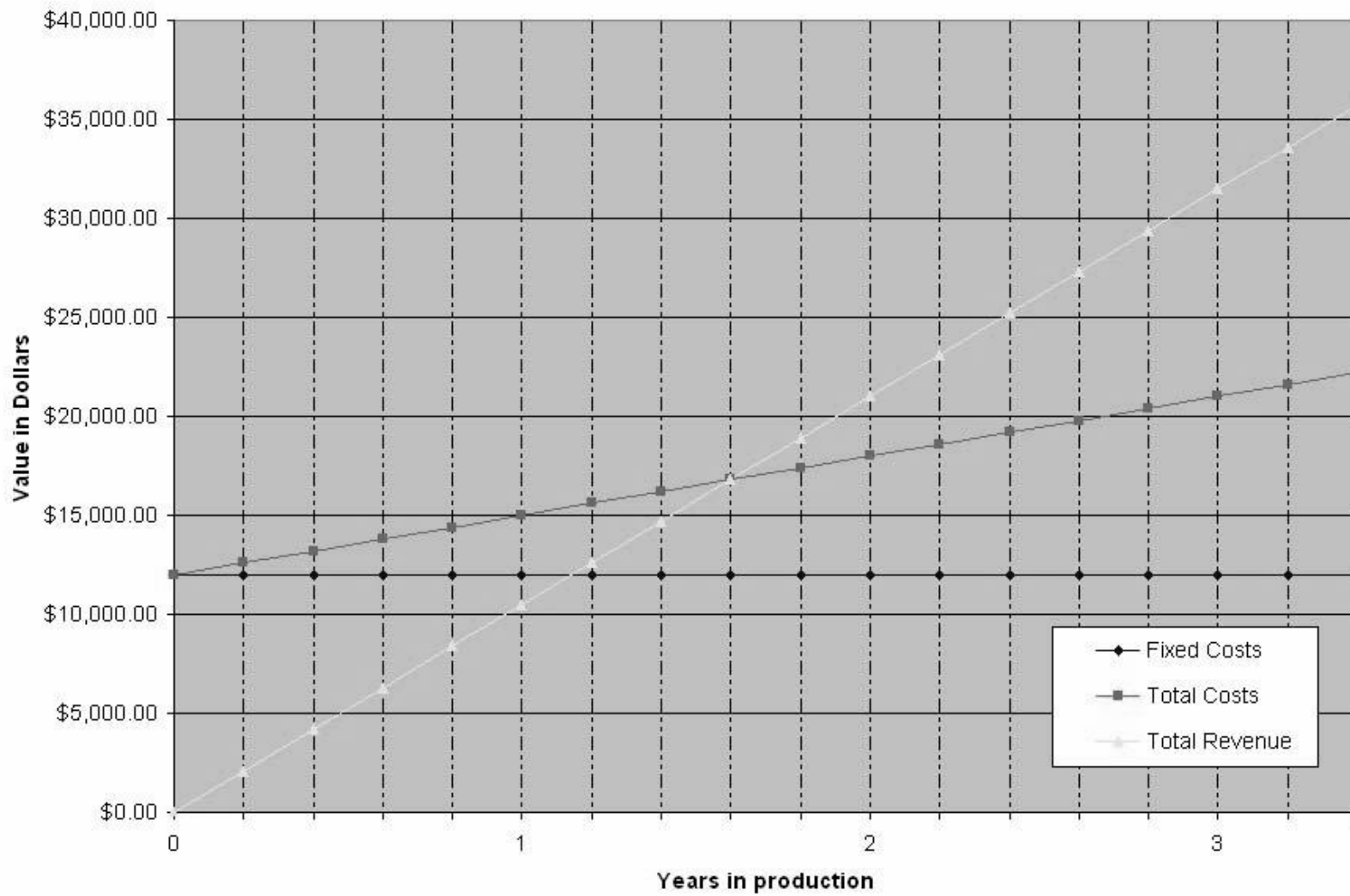
Kinkajou Power Supply

**Value Analysis**

	Market	Sola/Hevi-duty		Vicor		Meanwell		Acopian		WPI	
	Value point	Value point	Total	Value point	Total	Value point	Total	Value point	Total	Value point	Total
<b>Quality</b>											
1 Efficiency	3	3	9	1	3	2	6	3	9	2	6
2 Design	2	2	4	2	4	2	4	2	4	2	4
3 Warranty	3	3	9	1	3	1	3	3	9	3	9
Total			22		10		13		22		19
<b>Convenience</b>											
1 Size	2	3	6	1	2	3	6	3	6	3	6
2 Weight	2	3	6	2	4	3	6	2	4	3	6
Total			12		6		12		10		9
<b>Cost</b>											
1 Price	3	3	9	3	9	1	3	3	9	1	3
Total			9		9		3		9		3
<b>Customer Value: (Quality*Convenience/Cost)</b>			29.3		6.7		52		24.4		57

**Appendix D**  
**Return on Investment Graph**

### Return on Investment



**Appendix E**  
**Bill of Materials**

<b>Bill of Materials</b>			
Item	QTY	Value	Description
U1	1	LM2675	Simple Switcher 1A Step-Down Voltage Regulator
U2	1	LM348AP	IC OP AMP 741 QUAD 14-DIP
T1- T2	2		NPN Transistor 1A 35VCEO TO-126
SD1	1		Schottky Diode 40V 1A DO-41
LED1	1		LED 5MM HI-EFF RED TRANSPARENT
R1	1	res6.8k-5%-1/4	
R2	1	res2.7k-5%-1/4	
R3	1	1.8 Ohm	Resistor 1W 5% Metal Oxide
R4	1	res7.5k-1%-1/4	
R5	1	res5.1k-1%-1/4	
R6	1	res7.15k-1%-1/4	
R7	1	res4.99k-1%-1/4	
R8		res510-5%-1/4	
C1	1	22 uF	Electrolytic 50V 20%
C2	1	47 uF	Electrolytic 25V 20%
C3	3	0.01 uF	Ceramic 25V 10%
C4	2	.1uF	Electrolytic 50V 20%
D1	1	IN4001	Diode

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