

Post Mortem Report

For A New Designed Hybrid Bicycle



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1. Introduction &Background

Due to environmental issues generated by motor vehicles, the bicycle has become a more popular means of transportation among workers and students. However, one statistics report of bicycle marketing shows a very slow increasing trend of the bicycles use, which is almost a flat trend. The hybrid bike is the only type of bike that purchasing trend keeps increasing. But its battery limitation will definitely affect the sales volume and this may not be very convenient to riders as well. Therefore, we came up with the idea of a hybrid bike with energy conversion system, which can perfectly solve all these problems. This new designed hybrid e-bicycle has an attractive feature where its kinetic energy can be converted into electrical energy and stored in battery and vice versa. The stored electrical energy can be used as a power bank to charge phone and support some devices during a long trip. When riders encounter bad road conditions, the stored electrical energy will be converted to kinetic energy automatically to enhance the mobility of bicycles.

2. System overview

The HEB functions as both exercise bike and commuter bike in human's daily life. In order to make it a multi-purpose bicycle, there are two main systems which are propulsion system and power regeneration system. In the HEB, the propulsion system is consisted of pedals, sprockets, crank, chain, freewheel, rear axle, rear-wheel, hub motor and lead-acid batteries. Customers shall rotate the pedals to provide a human power which goes through cranks, sprockets, chain, freewheel, rear axle and eventually delivers the power to rear wheel. In addition, the BLDCM provides driving force to rear-wheel to assist propelling the bike. For the safety consideration, we design a new circuit for the power regeneration system which is separating with the propulsion system. We build 2 diodes

connecting with each phase on the BLDC motor. The diodes on 3 phases are stopping the current flow from the propulsion system to the regeneration system. In addition, we build a voltage regulator on the circuit which is keeping the voltage stable. The BLDC motor can create the current to charge the batteries when the bicycle is cycling or sliding.

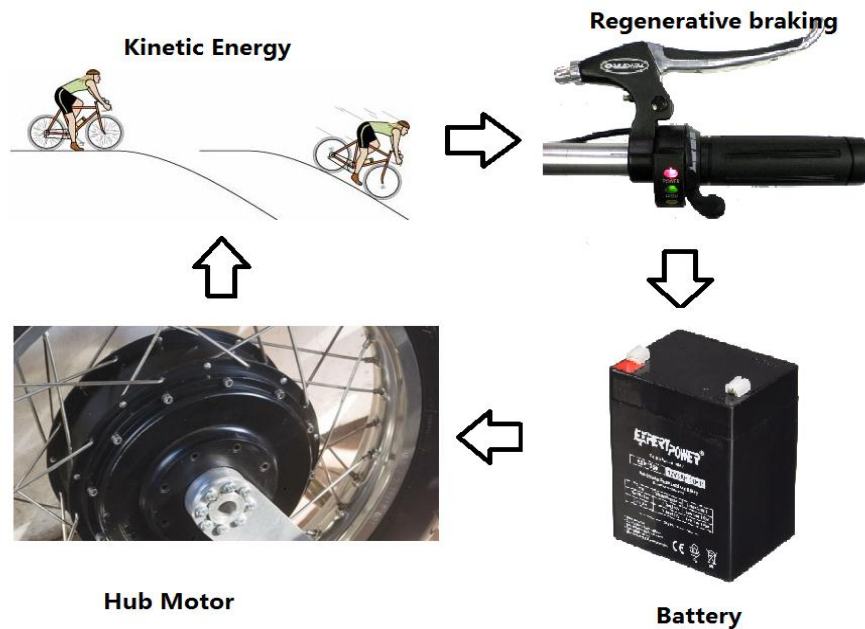


Figure 1. High level system diagram

Batteries are providing electric power to the BLDCM, which converts electric energy to Kinetic energy. A small portion of kinetic energy or the potential energy of the HEB can be further transformed back to the electric energy stored into the batteries.

3. Schedule

Time management is always one of the main challenges in every project. The Gantt charts below are our estimated and the actual timelines. We adjusted our schedule as our actual progress. We spent more time on our generation system

design because we did many researches for it and changing design necessarily. We also used much time for testing systems because our current and voltage are too high for generation system. Therefore we have to be careful for testing.

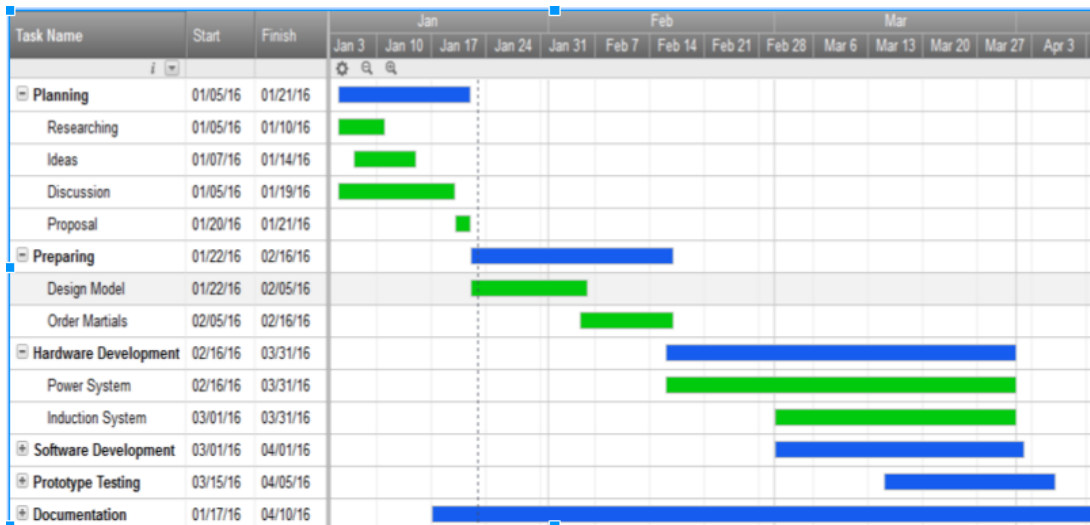


Figure 2 Estimated Schedule

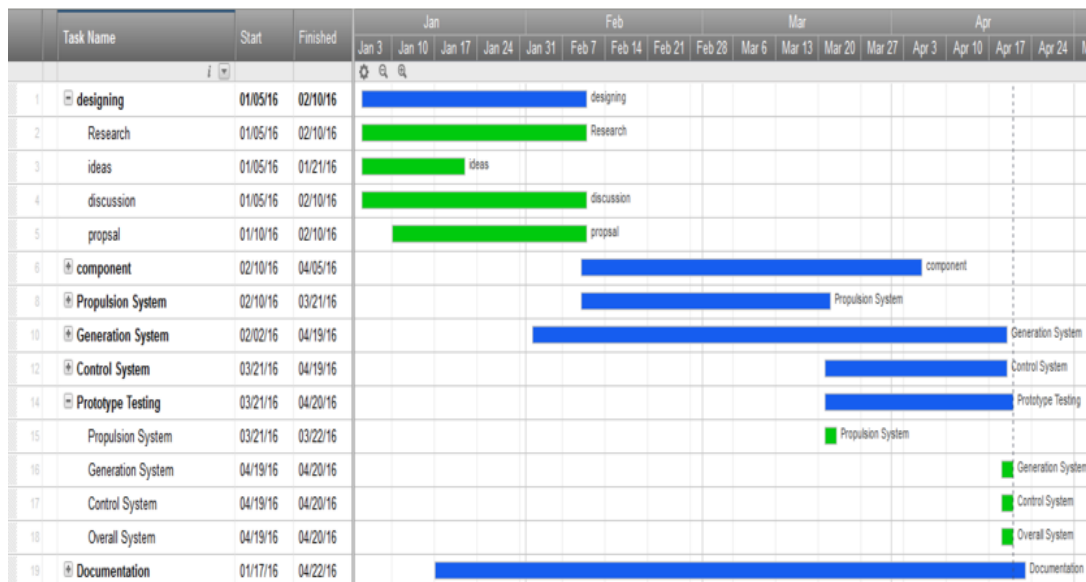


Figure 3 Actual Schedule

4. Budget

Table 1 and table 2 show the estimated budget and the actual budget. As the designing the project, we usually did many researches for each system then we always choose the useful and cheap components. Therefore the final budget is much cheaper than the estimated budget.

Table 1 Estimated Budget

estimated Equipment	Quantities	estimated cost
used bicycle	1	\$100
48V battery	1	\$240
brushless hub motor	1	\$200
250W induction motor	1	\$200
26" wheel	2	\$163
battery monitor	1	\$20
bicycle back rack	1	\$20
electric throttle	1	\$15
position sensor	1	\$12
bicycle switch	1	\$6
Arduino (Uno R3)	1	\$5
LCD for Arduino	1	\$5
infrared sensor	1	\$3
PCB board	1	\$2
Total	15	\$991

Table 2 Actual Budget

Actual Equipment	Quantities	actual cost
26''wheel & BLDC motor	1	\$356
12V battery	3	\$80
6V battery	2	\$20
current meter	1	\$14
Voltage regular	1	\$22
bicycle back rack	1	\$20
Reed sensor	3	\$12
switches	4	\$12
Arduino (Uno R3)	2	\$42
LCD for Arduino	1	\$12
wires	4	\$18
Prototype boards	4	\$27
Total	26	\$625

5. Market

In fact, there are just a few companies sale the generation bicycles. The generation bicycles are efficient than electric bicycles. When the E-Hybrid bicycle is 60 Km/h, the BLDC can need 1 hour to fully charge a 36V battery. The bicycle we used is the recycle bicycle and every normal bicycle can be adjusted to E-Hybrid bicycles. Therefore there will be good prospects for generation bicycles market.

6. Group dynamics

Coco Gong: system

Sheng sheng: electrical

Jim Zhang: UI

Jason: integration

Task	Coco	Sheng	Jim	Jason
Documentation	X	X	X	XX
Research and design	X	XX	X	XX
Ordering part		X	X	X
UI(software)	X	XX	X	X
UI enclosure	XX		XX	X
System integration	X	X	X	X
Testing and debugging	X	X	X	X

X = partial responsibility

XX = primary responsibility

7. Individual Reflections

Jason Li (CEO)

I am very grateful and honored to be the CEO of '4E Technology'. The company was formed by 4 Simon Fraser University students who are fourth or fifth year engineering students. I gain great experience to working with my team members in this challenging project. The past four months have provided me with a lot of

different experience from co-op, as with co-op you are usually given a set of tasks, a goal to achieve, and a few rules you must adhere to. With capstone, our team was in charge of everything from start to finish: the idea, design, implementation, and end goals. And this was sometimes tedious but, in the end, rewarding and pleasing. As with most teams, we started off with an ambitious project: an electrical bike that can achieve regenerative braking with adjustable braking rate and higher efficiency; however, after a few weeks of research and design, reality quickly set in with the first major reason of change in the design: the MOSFETs cannot be triggered by Arduino to control the motoring of the bike since the voltage required is apparently higher than the voltage provided. Even though we find the solution on building the regenerative braking system dealing with a 5V disc motor which is a 2 phase BLDC motor, but the circuit that could be working on a 5V motor can definitely not be working on the 500W BLDC motor. If we tried to build the circuit by replacing the transistor or resistors which could withstand higher current, more complex problems will arrive and we would be run out of time if we couldn't figure out the problems of the complex controller design. We are forced to think of alternatives to achieve the charging procedure. The EMF will be induced by the rotation of rotor while idling and the EMF will try to flow back to the battery direction, but the EMF will usually lower than the voltage of the batteries. A DC to DC voltage regulator is exactly what we need to boost the voltage to greater than 36V so that the batteries will be charged at that moment. The UI box was also required for the project. Even though we designed the box using Solidworks, we didn't use this method due to greatly higher costs and uncontrollability of the time of printing. We choose to use wood instead which only cost us \$18 on wood boards, wood nails and L-plate. Except for that, wood is easily adjustable compared to the 3D printed box. As a leader, I took effort on keeping the group united and fairly split the jobs. Though it was not an easily thing in the end. The most important things is to find the merit of each team member and always communicating with them to keep everyone up to date. Finally, I would like to thanks to every group members and our professors who

help me to finish ENSC 305W/440W. It was a very good time to work with others and I had learnt lots of skills

Sheng SHENG (CTO)

There are so many things I have learned from this four-month project. Though this project. I have not only designed and made circuits by using four-year university study, but also I need do more research, and find the information which I need for this project. This project let me have very good experience on a real world product designing and fabrication. And I think this is very important and have lots of meaning in my university study.

In the terms of technical skills, I have reviewed and learned the more things about electrical circuit. And an important thing is though this knowledge, I separated a whole project to so many small steps, I designed a product circuit by myself by step by step. Also, I studied and used Arduino to control this electrical circuit. I figured out problems in the circuit and software control test in several tests, and made every function work fine. I think I have accumulated extensive technical knowledge about electric circuits and device with software control and even testing skill.

On the other hand, One Important part I have talked is about the skill of figure out the problem by personal self, and gained the actual experience about electrical circuit design. In Four-Year University study, I may study lots of software and hardware conception, knowledge. Although we have some labs, but this all works which are followed professor step. This Cap Stone project is first project I do everything by my own self. In the process, I find lots of problems which I need figured out by myself, sometimes, I even need reworked this whole step again to find the solution. Follow this process, I think have gained some actual experience in the work, such as after I spend the lot of time to work on the propulsion system and regeneration system, and made them work fine, but when I integrated this two system together, the circuit have burned because of inrush current. I deeply understand although I have studied lots of conception, knowledge of circuit design in university, but I still have so many conditions I cannot consider in work.

In short, I really enjoy working on this project, although the presentation and demo result is not very good. I think this experience will benefit in my life.

Yuanjie Zhang (COO)

The capstone project course is one of the most important courses in the Engineer undergraduate program. I heard from my friend who has taken this

course before that this course has to spend much time. Staying in lab for the whole day is normally thing in the last moth of the semester. Our project is to adjust existing products and add more efficient features in it. We have to huge large of researches for the designing. In fact, all of us didn't build the similar project before. Therefore teamwork and patient become more important in order to be successful in the course. I'm an Electronic student who has taken many courses for circuit design and materials selection. However, I found I still face many problems I have never seen before. I still have more knowledge to learn. My group members helped me a lot about circuit design and coding design. We have good teamwork on our generation system design and control system design. In our project, we spend much time for our generation system and control system. The BLDC motor is 500W. It has high current and high voltage. We should totally cut down the circuit when the generation system is working. In generation system, we used 6 diodes and voltage regulator to connect 3 phases which can ensure the BLDC motor can recharge the batteries. In the control system, we choose 4 SDST switch relay to totally cut the circuit when another circuit is working. Finally we built two wooden boxes to cover our circuit. This course gave me a valuable experience on teamwork and solving problems which I won't learn from lectures and exams. Finally we have successfully completed our project and I'm so glad to work with my team before graduation.

Coco Dong (CFO)

First of all, I should admit that I am pretty proud to be one of the four talent people in 4E Technology Inc., and I really enjoy the time to work for our project this semester even if everyone exhausted in the end. Our project is to build a hybrid e-bike, which is very complex that need us to figure out several working systems. Although our final presentation was not so good due to varies reasons, and our demo was 2 hour later than the required time, I am still happy that we finally achieve the initial goal we set up at the very beginning of this project, and all functions we expected work well during demo time. As CIO of the company, I focused more on information collecting and market analyzing. Since during my

previous coop work, I did some workshop of ecommercial and market analyzing, I am very sensitive in this area, to make our product more competitive. During the time we work on our project, like propulsion system and control system, I behaved more like a lab assistant to help our CTO to assembly and testing the circuits. This is mainly because of my limited experience to apply my available knowledge on a real application, though I am already a 4-year System Engineering student. However, I still learned a lot during this procedure that I did a lot self-study things about bicycle driving system, generating system, propulsion system, etc. Also, I improved my software skill a little bit by learning Arduino code. Besides the technical skills I have learned or improved, I have also earn some valuable experience in team working. Even this is not the first time to work as a team, I am still impressed by the strong power generated by group work. During the team work, I also reviewed the method for solving tough problem: Iterations of sub-system (simple questions), which is efficiency and convenient for someone like me, that with limited technical knowledge, who cannot directly achieved the final target. Last but not least, I would like to thank all my group members that they really help me a lot during the time I was in bad body condition. There are just four people in our team, which means that the task for everybody is almost equally heavy. However, when I suffered in bad sickness, they shared responsibility of mine automatically to reduce my pressure, and never asked me to any heavy or complex work, even if I get well completely. It is pretty warm to work with them and learn from each other. It will be hard for me to forget this experience, not only because this is my first technical project in my life, but also because these nice people, Jason, Jim and Sheng Sheng, as well as those unforgettable warm memories.

Appendix

4E Technology Inc.

Time: January 14, 2016 16:00 – 17:30

Position: ASB

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: To discuss the idea of project

Items for Discussion:

- Team members greeting
- Project topics selection
- Overview of the project

MINUTES:

A. Meeting team members

Action: Exchange contacting methods each other.

B. Project topics selection

Discussion: choose the best idea from several options collecting from all members

- Cervical Treatment Instrument
- Automatically Owner Following Suitcase
- Multifunction Crutches

Action: The topic “Automatically Owner Following Suitcase” has been chosen

C. Project Overview

Discussion: what is the overview of project, and possible systems

Action: to research information at home and discuss next meeting.

4E Technology Inc.

Time: January 19, 2016 16:00 – 19:00

Position: LAB #4

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: To establish the plan for proposal due next Monday

Items for Discussion: Project proposal planning

MINUTES:

A. Project proposal planning

Discussion: With the reference of Review rubric, split up the work for proposal

Action:

- Coco- letter of transmittal, title page, executive summary, T of C, Introduction
- Jason- Explanation of key elements of proposal, references
- Jim- Budget, team roles description, conclusion
- Sheng- Analysis of need, market and competition, time schedule

B. The project idea changed

Discussion: new topic of our project: hybrid e-bike

Action: re-do information researching for our new topic

4E Technology Inc.

Time: February 5, 2016 18:30 – 21:00

Position: LAB #1

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: To discuss the purpose of the project and figure out the high level function description

Items for Discussion:

- Purpose of the project
- High level function description

MINUTES:

A. Purpose of the project

Discussion: Consider the features of our project product and prepare for function specifications

Action:

- Energy- convertible working system
- Function specifications preparing and information researching

B. High level function description

Discussion: Talk about how the project work and split to sub-systems for future work.

Action:

- Draw a high level functional block diagram
- Split to three main parts according to the functional specifications

4E Technology Inc.

Time: February 19, 2016 16:30 – 20:00

Position: LAB #4

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: Work together to finish the function specifications

Items for Discussion:

- Function specifications
- The project parts we need

MINUTES:

A. Finish up the function specifications paper before due time

Action:

- All members work together for final draft and edit the format
- Coco- Letter of transmittal, title page, executive summary, T of C, glossary, introduction, conclusion
 - Jason- Overall system requirements, reliability and safety, references
 - Jim- Propulsion, power regeneration, control system
 - Sheng- reliability and safety, user documentation

B. From the function specifications and information we get, list all parts we may need for project

Action:

- Search and compare the item price from Ebay, Amazon and Alibaba
- Order the parts online or local industrial market

4E Technology Inc.

Time: February 24, 2016 18:30 – 21:00

Position: LAB #1

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: Design and Simulate Generation System of Hybrid e-bike

Items for Discussion:

- What is the generation system?
- Necessary parts need to build circuit
- Simulate the generation system

MINUTES:

A. With the information collecting before meeting, each member should be able to understand what the generation system is, the parts to simulate the generation system.

Action:

- Draw the circuit of generation system
- Simulate the function with predetermined parts
- Test and improve the design.

4E Technology Inc.

Time: March 7, 2016 13:00 – 18:00

Position: LAB #4

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: To finish the Design Specification by collecting all works from each member

Items for Discussion:

- Combination of all individual work
- Grammar and formatting correction

MINUTES:

A. As discussed before meeting, each member write up their own parts and come together to discuss any improvements.

Action:

- Combine the sections done by members to one final draft
- Grammar and formatting correction
- Discuss the system overview, as well as overall system design, propulsion system design, generation system design and periphery system design. And then some improvement can be done to better the design specification.

4E Technology Inc.

Time: March 17, 2016 16:00 – 18:00

Position: LAB #1

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: Design and Simulate Propulsion System of Hybrid e-bike

Items for Discussion:

- What is the propulsion system?
- Necessary parts need to build circuit
- Simulate the propulsion system

MINUTES:

A. With the information collecting before meeting, each member should be able to understand what the propulsion system is and understand which parts to simulate the propulsion system.

Action:

- Draw the circuit of propulsion system
- Simulate the function with predetermined parts
- Test and improve the design.

4E Technology Inc.

Time: March 31, 2016 14:00 – 18:00

Position: LAB #1

Present: Jason, Sheng, Jim

Absent: Coco (sickness)

AGENDA:

Purpose of Meeting: Design and Simulate Control System of Hybrid e-bike

Items for Discussion:

- What is the control system?
- Necessary parts need to build circuit
- Simulate the control system

MINUTES:

A. With the information collecting before meeting, each member should be able to understand what the control system is and understand which parts to simulate the control system.

Action:

- Draw the circuit of control system
- Simulate the function with predetermined parts
- Test and improve the design.

4E Technology Inc.

Time: April 7, 2016 15:00 – 18:00

Position: LAB #1

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: Use the Arduino to control all sub-systems

Items for Discussion:

- What is Arduino?
- How to use Arduino code to control each system?

MINUTES:

A. Share the information of Arduino and discussion how to use Arduino Uno as a main controller for our project.

Action:

- Search information online and self-study the Arduino code
- Try to write Arduino code and simulate on Arduino Uno to control all sub-systems
- Test and re-design the code in order to better achieve the functions

4E Technology Inc.

Time: April 16, 2016 13:00 – 18:00

Position: Underwater Research Lab, Lab #1

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: To finish assembling the prototype and testing

Items for Discussion:

- Holder boxes
- Final prototype and test
- Presentation for demo

MINUTES:

A. We got the feedback from 3-D printer professor that it is not necessary to use 3-D printing to get a box, we can just use wood board to make one.

Action:

- Jason, Jim and Coco – make two designed size boxes.
- Sheng – Continue to test the prototype

B. After successful testing of each part, combine them together.

Action:

- Test all functions of final prototype product
- Use the boxes to hold PCB and LCD boxes.

C. Do preparations for presentation

Action:

- Make a PPT for tomorrow
- Separate the presentation to several parts and assign to each members
- Coco- Introduction, Motivation, Conclusion, Reference
 - Jason- Project Overview
 - Jim- Budgets and schedule, Market
 - Sheng- Troubleshooting

4E Technology Inc.

Time: April 20, 2016 11:00 – 20:00

Position: LAB #1

Present: Jason, Sheng, Jim, Coco

AGENDA:

Purpose of Meeting: Final prototype testing and post-mortem analyzing

Items for Discussion:

- Testing for the final prototype
- Post-mortem

MINUTES:

A. Keeps testing for out final prototype based on test plan

Action:

- Compared the actual results with our expected solutions
- Reconnecting all wires to make sure all parts work well

B. Before writing the post-mortem paper, discuss about what we learn from the class and project.

Action:

- Colleting all answers and put down to the paper
- Finish the paper together through google drive before 8:00am, Apr.23