DESIGN OF ELECTRONIC BALLAST OF ONE BALLAST-TWO LAMP SYSTEM USING RAPID START TECHNIQUE

By

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FINAL PROJECT REPORT

Submitted to the Department of Electrical & Electronic Engineering
in Partial Fulfillment of the Requirements
for the Degree
Bachelor of Engineering (Hons)
(Electrical & Electronic Engineering)

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CERTIFICATION OF APPROVAL

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Approved:

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Dr Nor Zaihar Bin Yahaya
Project Supervisor

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TRONOH, PERAK

May 2012

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Norul Hashimah Binti Ali

ABSTRACTS

This project is about designing electronic ballast of one ballast–two lamp system using rapid start technique. Rapid start technique will start lamps quickly without flicker by heating the lamps electrodes and simultaneously applying the starting voltage. Rapid start technique is chosen because it provides a low starting voltage about 3.5 volts to the electrodes for one second before lamp ignition. The proposed circuit design consists of full bridge rectifier and boost converter, as a power factor correction (PFC) stage, integrate with a resonant half bridge inverter, used as lamp power control stage. Two lamps connection in parallel will be used as load to verify the objective. All the development of designing electronic ballast using one ballast–two lamp system with rapid start technique and the simulation will be through Multisim. This project is aim to design and improve the electronic ballast based on initial voltage and initial current. It is found that the current to the load is lower when two lamps are used.

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CHAPTER 1: INTRODUCTION

1.1 Background project

Ballast is a device used in fluorescent lamp and other discharge lamps to provide the required current and voltage to turn on the lamp. The primary function is to provide the lamp with high voltage (depend on the type of ballasts) or cathode heating during start-up, and then to stabilise the arc (spark) by limiting the electrical current to the lamp. [1]

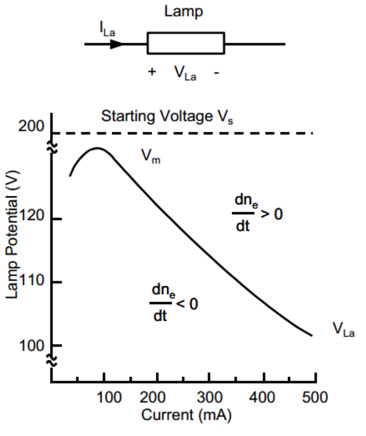

Figure 1: Discharge potential drop versus current [2]

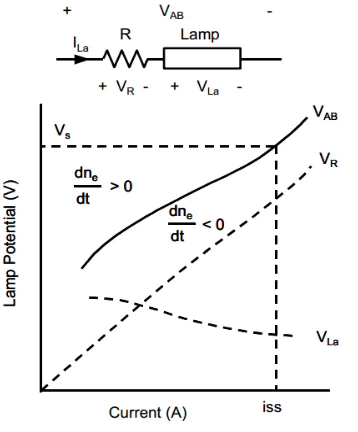

Figure 2: The effect of series resistance in stabilizing lamp current [2]

Figure 1 shows a typical curve of discharge potential drop versus current when a lamp is operated from DC power source and figure 2 shows the effect of series resistance in stabilizing lamp current. Gas discharged lamps cannot be directly connect to a voltage source, certain impedance must be placed between discharged lamp and the voltage source as means to limit lamp current.

There are two basic types of ballasts: low-frequency magnetic ballasts and high-frequency electronic ballasts. The functions of these two types of ballasts are essentially the same, that is, they control the starting and operating characteristics of the electricity for fluorescent lamp. Electronic ballast is an AC-DC-AC conversion system which converts the AC power from sinusoidal waveform at 50 - 60 Hz to square waveform at above 20 000 Hz using an inverter and power conditioning circuits. The electronic ballast is also used to provide current limitation, and improve power factor using Power Factor Correction (PFC) Boost converter. [3]

There are three types of starting method of electronic ballast; one of them is rapid start technique. Rapid start ballast will start a lamp by first heating the cathode and will maintain a constant arc across the cathode to optimize the heat necessary for proper operation, due to these lamps tend to be longer lived with rapid start ballast, for frequent ON-OFF lamps. [4, 5]

1.2 Problem statements

Nowadays, electronic ballasts are being widely used in lighting applications, especially to supply fluorescent lamps at high frequency (above 20,000 Hz), compactness, and dimming capability. However, high starting current occurs when the electronic ballast is first switched on. High starting current (approximately 0.93 mA) typically exceeds the current limits of the relay, which often is designed to handle only up to 10 times the normal operating current. The high peak current of starting current can have adverse effects on the lighting system. It can affect the relay contacts, the circuit breaker, and other related components. Repeated exposure to the stress of starting current can shorten the operating life span of these elements. [6]

Instant-start electronic ballasts provide a high initial voltage (typically 600V) to start the lamp. This high voltage is required to initiate discharge between the unheated electrodes of the lamp. However, the cold electrodes of lamps operated by an instant-start ballast may deteriorate more quickly than the warmed electrodes of lamps operated by a rapid-start, program rapid-start or programmed-start ballast. Lamps operated by instant-start ballasts will typically withstand 10-15K switch cycles. [7]

1.3 Objectives

i. To design, simulate the new design electronic ballast using one ballast–two lamp system with rapid start technique

ii. To observe and analyse the starting voltage and starting current of the design project.

1.4 Challenges

To date, a common electronic ballast circuit is equipped with filter system. However, the filter features still do not prevent the affected performance problem since the circuit will operate at high frequency. The starting method for electronic ballast circuit is quite similar for rapid start, instant start and programmed start technique in term of design circuit. It is quite challenging to identify the best procedure that should be used for the project although these techniques have differences in term of the connection between ballast and lamp due to the different equipment and material used. The rapid start technique is noted that it has many advantages compared to the others, yet, still do have drawbacks such as the type of lamp connection that will affect the project's result.

1.5 Significant of project

The idea of the project is to design, develop and implement the new design electronic ballast using one ballast–two lamp system with rapid start technique. The aim is to extend the life span of the lamp. Rapid start technique is seen to be a reliable starter that provides continuous lamp filament heating provided by the ballast after the lamps are started. Because of the continuously heated electrodes, less voltage is required for the initial surge to start the lamp that will reduce the energy cost.

1.6 Project contribution

The primary advantage of electronic ballasts is that they draw less power and therefore provide energy savings for green technology. For example, magnetic ballasts consume 12 or 13 watts internally, whereas the electronic ballasts may consume only 4 watts. The lower power consumption also means that there is less heat generated by the ballast resulting in lower operating temperatures. The lower fixture temperatures and high frequency operation causes the lamps, themselves, to operate up to 10% more efficient. Electronic ballast is also considered as economic feasible because it operates at lower temperatures than magnetic ballasts, increasing lamp life, and reducing air conditioning and maintenance costs.

1.7 Scope of project

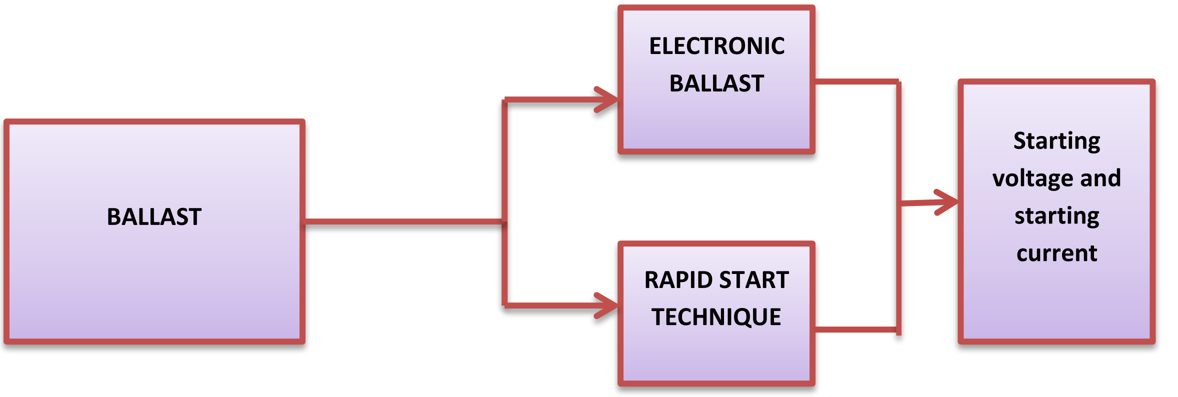

Figure 3: Scope of studies

The scope of study for the project is described as in figure 3. The study will be focusing on the electronic ballast and will cover rapid start technique as the main starting method which will be used on the lamp that is connected in series. Electronic ballast using rapid start technique is then will be analysed based on performance in starting voltage and starting current.

CHAPTER 2: LITERATURE REVIEW

2.1 Types of ballast

Electronic ballast uses integrated circuitry to perform all functions of the ballast. It rectifies the 60 Hz AC input to DC and then produces a very high frequency current (20,000 - 50,000 Hz) using an inverter and power conditioning components. In most models, the electronics are also used to provide current limitation, and improve power factor. **Magnetic ballast** is simple inductive ballasts which consist of coils of copper wire wound around iron cores. Alternating current passes through the turns of the copper wire, creating a strong magnetic field. The magnetic field reverses its polarity 120 times per second when operating on 60-hertz AC. The resulting reactance opposes a change in current flow and limits the current to the lamp. [8]

In the early 1980s, electronic ballast was introduced to replace the magnetic ballast that operates lamps at 20- 60 kHz. These electronics ballast have approximately half the power loss of magnetics ballast. Electronic ballasts are higher in cost than magnetic ballast types and they can reduce wattage approximately 10-15 W compared to magnetic ballast. Electronics ballast is also quieter, often lighter, and can eliminate lamp flicker. [9]

As advance technology introduces, and more research was done, in 2010, Florian Giezender was producing the Electromagnetic Interference (EMI) noise prediction for electronic ballast. In this project, the circuit of electronic ballast was divided in three stages that is input stage where it contains EMI filter and full bridge rectifier, the second stage is Power Factor Correction (PFC) that contains boost converter to suppressed the harmonic current due to the rectification process, and the third stage is output stage that contains half- bridge inverter as shown in figure 4. [10]

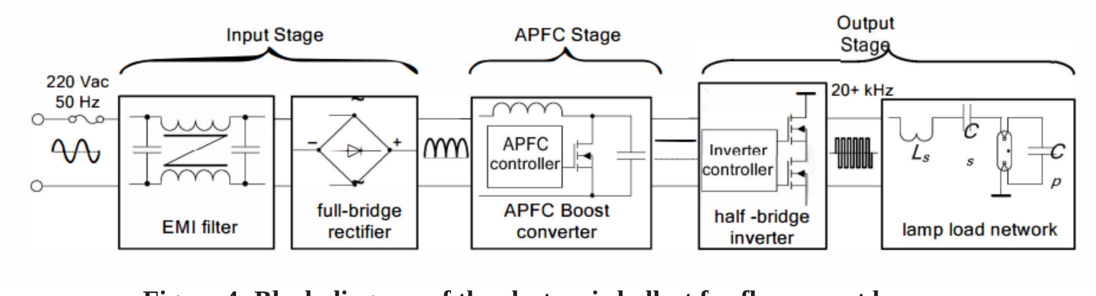

Figure 4: Block diagram of the electronic ballast for fluorescent lamps

In 2011, Ultra-Low-Loss magnetic Ballast was introduced. The electronic ballast has shorter lifetime because of electrolytic capacitors commonly used in electronic circuits of lighting applications. This has been a serious concern, because it limits the lifetime of the entire lighting products. Typical rated lifetimes of electronic ballasts for compact and tubular fluorescent lamps are 10 000 hr and 15 000 hr (1.7 years), respectively. Such short lifetimes mean that a huge amount of electronic waste would have been accumulated due to the use of these electronic ballast products. [11]

Table 1: Comparison between electronic ballast and magnetic ballast

Types of ballast	**issues**	**advantages**
Electronic Ballast	1.Have short life time [6] 2. higher in cost [2]	1. Half the power loss of magnetics ballast.[2] 2. Reduce wattage up to 10-15 W compared to magnetic ballast. 3. Lighter 4. Can eliminate lamp flicker [2] 5. Improve power factor [2]
Magnetic Ballast	1. Can only limit voltage and not frequency 2. Caused lamp flicker	1. Sustainable lighting because of inductor core and winding can be recycled at the end of the product lifetime. 2. Reliable electrical and mechanical performance 3. Quick and easy wiring 4. Optimum lamp performance under optimum temperature conditions.

From Table 1, it is observed that electronics ballast have some advantages such as lamp flicker elimination and power factor improvement. Due to this the electronic ballast can reduce the power loss and energy saving. Although electronic ballast possesses more advantages, they are much costly due to the application of electronic components such as capacitor, buck converter and etc.

2.2 Ballast starting method

a) Rapid start ballast will start a lamp by first heating the cathode and will maintain a constant arc across the cathode to maintain the heat necessary for proper operation. This is mandatory for any dimming operation. Dimming is impossible using instant-start ballast. The rapid-start ballast is easier on the cathode in the starting mode; when there are many on-off cycles because occupancy sensors control the lights, lamps tend to be longer lived with rapid-start ballasts. [12]

b) Instant-start ballasts have caused premature failure of the lamps because of the high voltage they use to "jump start" the lamps. This high-voltage blasting of the cathode causes sputtering—clumps of tungsten are blown off the cathode and coat the ends of the lamp, causing them to appear black. This blackening occurs with all lamps as they age, but it occurs more rapidly when instant-start ballast is in operation and the lamp is turned off and on many times a day. [13]

c) In 1999, A Novel Parallel-Resonant Programmed Start Electronic Ballast was introduced by Bryce L. Hesterman[8], Bryce L. Hesterman stated that the programmed starting method minimizes damage to the lamp filaments during starting by providing adequate filament heating before striking the lamps. It limits the voltage across the lamps during the preheating interval to a level that prevents a glow discharge from being initiated. Many programmed start ballasts also reduce the filament voltage after striking the lamps in order to save energy.

d) International Conference on 2009, tittle "Electronic Ballast of the Electrode-less Lamp for the Group Lighting System" proposed one-ballast two-lamp system to reduce cost due to the cost of RF modem is relatively expensive compared to the electronic ballast. Figure 4 is about the proposed control circuit of the ballast that implemented with fully digital circuit using low cost 16-bit digital signal processing (DSP) and small size electrically programmable logic device (EPLD). Detailed algorithms for the power control and protections for the commercial electronic ballast are described. Finally, the wire and wireless linked group lighting system using the proposed ballast is introduced. [14]

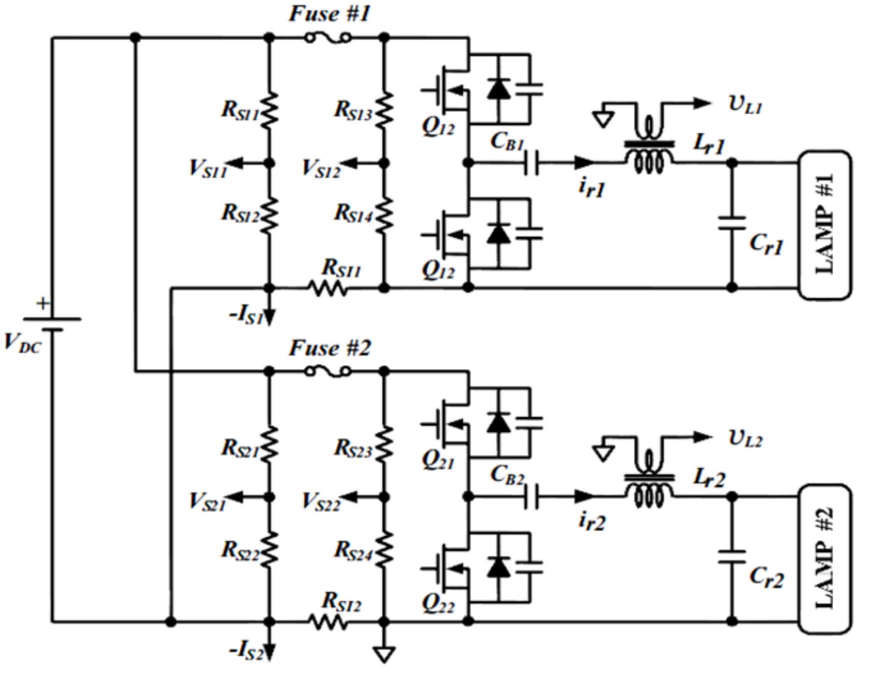

Figure 5: Electronic ballast circuit [11]

Figure 5 shows the circuit of the proposed one-ballast two-lamp system by KyuminCho [11]. Two half-bridge resonant inverters are driven by a DC link. V_{S11}, V_{S12}, V_{S21}, and V_{S22} are used for dc link voltage monitoring, fuse status monitoring, and over/under voltage protection. I_{S1} and I_{S2} are used for used for dc current monitoring and power calculation of each inverter. V_{L1} and V_{L2} are used for protection of switching devices in the ignition state and lamp fault state.

V_{S11}, V_{S12}, V_{S21},V_{S22} = DC link voltage

I_{S1}, I_{S2}=Dc current

Table 2: Comparison methods of ballast starter

Starting method	issues	advantages
1. Rapid start	1. Connection in series that can cause one lamp fails, all other lamps in the circuit will extinguish [4].	1.longer lived 2. low starting voltage 3.striking an electrical arc inside the lamp 4. Withstand 15-20K switch cycles
2. Instant start	1. High initial voltage 2. Withstand 10-15K switch cycles	1. provide maximum energy savings 2. start lamps without delay or flashing 3. Consume less energy. 4. Connection in parallel. This means that if one lamp fails, the other lamps in the circuit will remain lit.
3. Programmed start	1. Connection in series that can caused one lamp fails, all other lamps in the circuit will extinguish 2. High cost	1. provide maximum lamp life in frequent starting conditions

From Table 2, it is concluded that rapid start, instant start and programmed start starting method have their own advantages and disadvantages. The starting method is compared based on number of switch cycles, the types of lamp connection (either series or parallel) and initial voltage.

Traditional fluorescent lamp will produce high peak current will cause damage the lamp electrode and reduce the lamp life [12]. Electrodes deterioration will affect the lamp and will cause the energy losses. Buck – boost converter was introduced as a one of the control scheme to provide a better power factor correction [13].

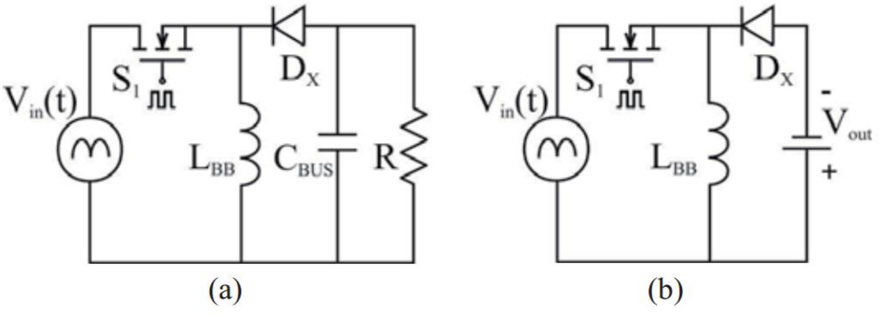

Figure 6: Buck – boost topology [13]

This converter can operate as a voltage step down and step up, depending on duty cycle that given to the circuit.

2.3 Two stages electronic ballast

On 2001, two stages electronic ballast show in figure 7 was introduced by Corominas, E.L [14] that consists of Power Factor Correction (PFC) stage and inverter stage. PFC stage Buck DC-to-DC converter operating in Discontinuous Conduction Mode (DCM) to meet with the IEC-100-3-2 Class C requirements.

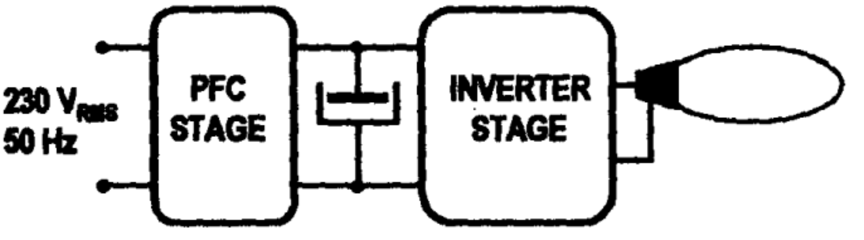

Figure 7: Typical block diagram of an electronic ballast [14]

2.4 Full bridge rectifier

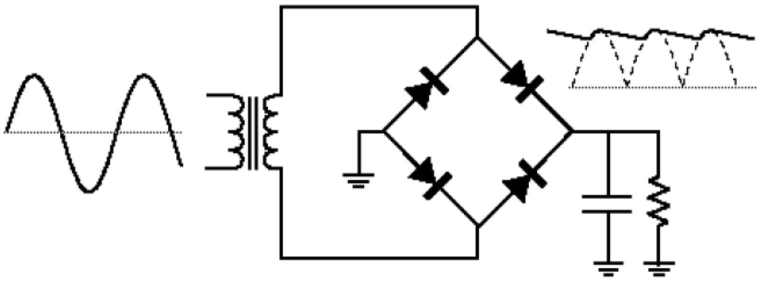

Figure 8: Full bridge rectifier

A bridge rectifier makes use of four diodes in a bridge arrangement to achieve full-wave rectification. Bridge rectifier is used to convert AC power to DC power.

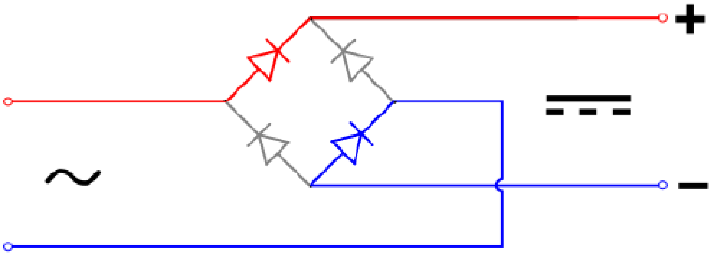

Figure 9: Positive half-cycle rectification

When the input connected at the left corner is positive with respect to the one connected at the right hand corner, current flows to the right along the upper coloured path to the output, and returns to the input supply via the lower one.

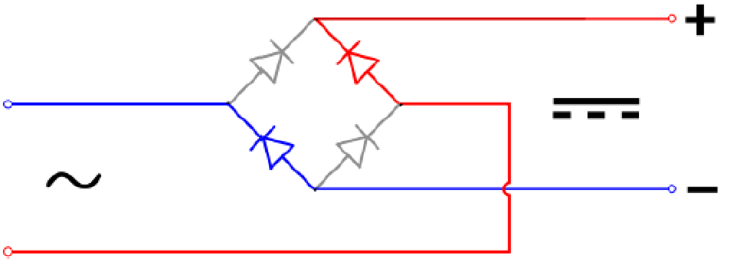

Figure 10: Negative half-cycle rectification

When the right hand corner is positive relative to the left hand corner, current flows along the upper coloured path and returns to the supply via the lower coloured path.

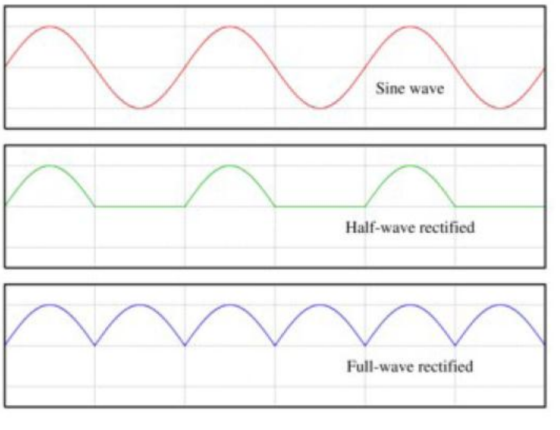

Figure 11: AC, half-wave and full wave rectified signals

In each case, the upper right output remains positive with respect to the lower right one. Since this is true whether the input is AC or DC, this circuit not only produces DC power when supplied with AC power: it also can provide what is sometimes called "reverse polarity protection". That is, it permits normal functioning when batteries are installed backwards or DC input-power supply wiring "has its wires crossed" (and protects the circuitry it powers against damage that might occur without this circuit in place).

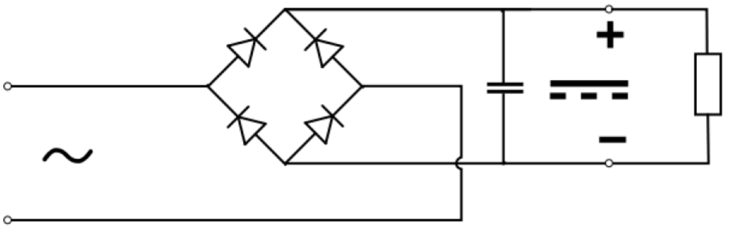

Figure 12: Buffer capacitor

For many applications, especially with single phase AC where the full-wave bridge serves to convert an AC input into a DC output, the addition of a capacitor may be important because the bridge alone supplies an output voltage of fixed polarity but pulsating magnitude as shown in Figure 12.The function of this capacitor, known as a 'smoothing capacitor' is to lessen the variation in (or 'smooth') the raw output voltage waveform from the bridge. One explanation of 'smoothing' is that the capacitor provides a low impedance path to the AC component of the output, reducing the AC voltage across, and AC current through, the resistive load. In less technical terms, any drop in the output voltage and current of the bridge tends to be cancelled by loss of charge in the capacitor.

This charge flows out as additional current through the load. Thus the change of load current and voltage is reduced relative to what would occur without the capacitor. Increases of voltage correspondingly store excess charge in the capacitor, thus moderating the change in output voltage / current. The capacitor and the load resistance have a typical time constant $\tau = RC$ where C and R are the capacitance and load resistance respectively. As long as the load resistor is large enough so that this time constant is much longer than the time of one ripple cycle, the above configuration will produce a well smoothed DC voltage across the load resistance.

The idealized waveforms shown above are seen for both voltage and current when the load on the bridge is resistive. When the load includes a smoothing capacitor, both the voltage and the current waveforms will be greatly changed. While the voltage is smoothed, as described above, current will flow through the bridge only during the time when the input voltage is greater than the capacitor voltage. For example, if the load draws an average current of n Amps, and the diodes conduct for 10% of the time, the average diode current during conduction must be 10n Amps. This non-sinusoidal current leads to harmonic distortion and a poor power factor in the AC supply. [15]

2.5 Half bridge inverter

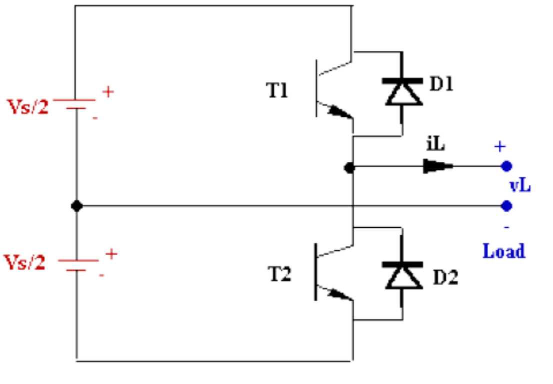

Figure 13: Half Bridge Inverter

When transistor T1 is ON, a voltage Vs/2 will be applied to the load. If the load draws positive current iL it will flow through T1 and supply energy to the load. IF the load current iL is negative it will flow back through D1 and return energy to the DC source. Similarly, if T2 is ON -Vs/2 will be applied to the load. If iL is positive it must flow through D2 returning energy to the DC source. If the current is negative it must flow through T2 supplying energy to the load.

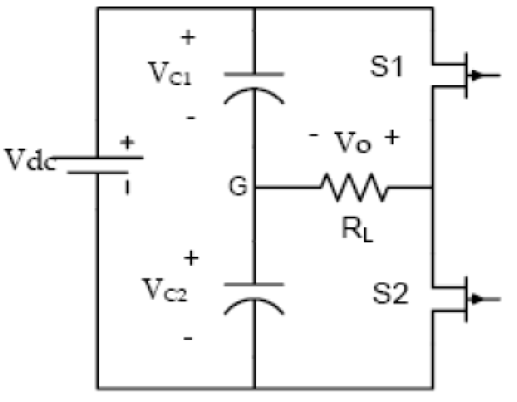

Figure 14: Center-tapped half bridge inverter

Both capacitors are equal and very large in capacitance values, so that time constant *RC1* is much larger than the half switching period. This will guarantee that the midpoint, G has a fixed potential at one-half of the supply voltage Vdc. Circuit uses the half of dc supply voltage. Hence, its output voltage and power are twice less than compared to other circuits.

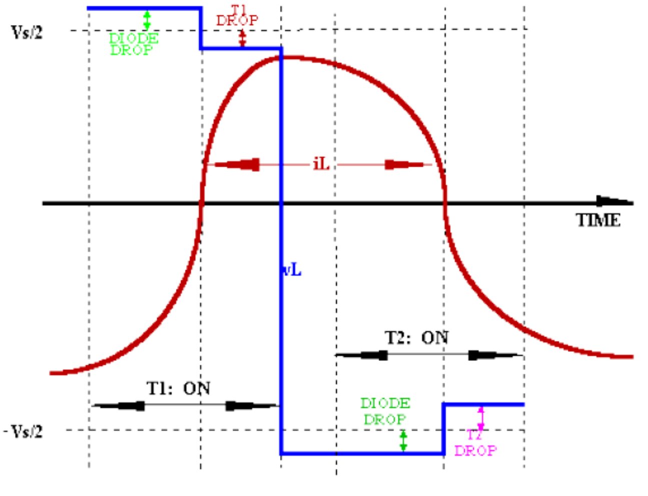

Figure 1 5: Conduction Pattern for inverter

With T1 ON and drawing positive load current iL the load voltage will be less than Vs/2 by the ON-STATE voltage drop of T1. When the load current reverses, the load voltage will be higher than Vs/2 by the voltage drop across D1. Normally the ON-STATE voltage and diode drops are ignored and the centre tapped inverter is represented as generating the voltage + Vs/2 or - Vs/2. [16]

CHAPTER 3: METHODOLOGY

3.1 Research Methodology

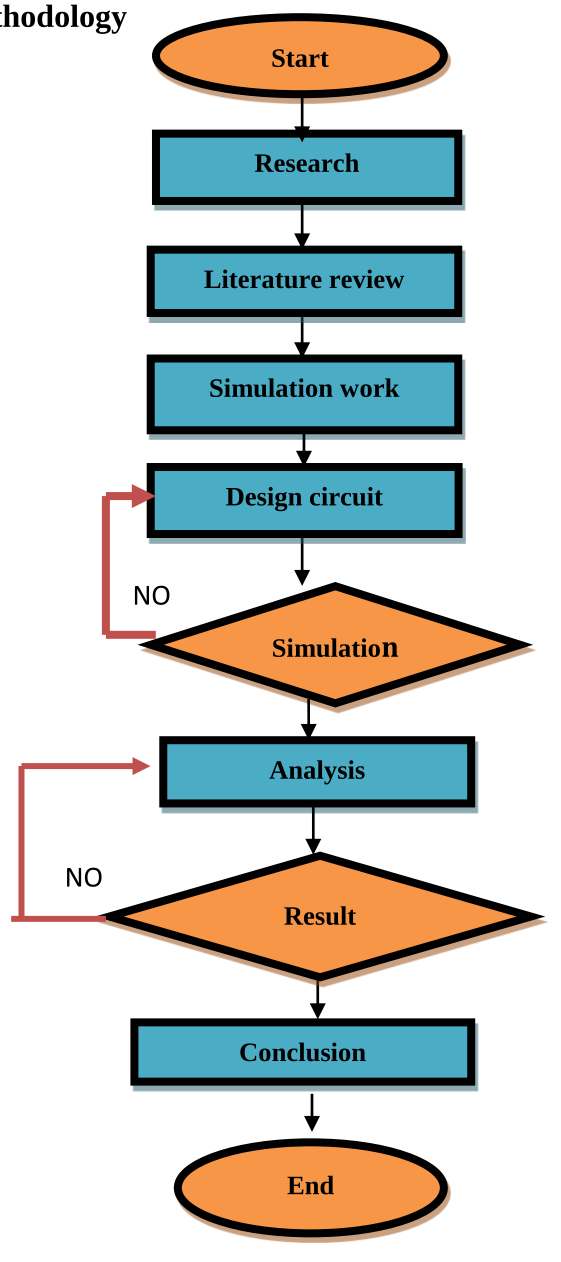

Figure 16: Flowchart of project

Figure 16 shows the flow chart of the project. From the flow diagram, the steps and direction of the project can be clearly seen. It has been designed to fully utilise the time frame given to complete the project. The flow chart as well, will help in developing and making the project successful.

3.2 Project activities

Table 3: Project Work Description

Methodology	Description
Research	Conduct research on type of ballast, electronic ballast, starting ballast method.
Literature review	Making clear the objective of the project. Outlining the direction by referring to the research that has been done. Afford to understand what the type of ballast was been used in the past and what can be improved for the next ballast design. Expectation is clearly stated at this methodology.
Experimental work	To do a simulation on the basic electronic ballast circuit.
Design circuit	The electronic ballast will be designed to meet expectation of the objective.
Simulation	Simulation is done using Multisim.
Analysis	The performances of the electronic ballast will be analysed and the success will be determined by comparing to the current, voltage and power losses of other electronic ballast. The new electronic must give better performance compared to the other electronic ballast.

Table 3 describes the project activities in conducting FYP I and FYP II. The methodology begins with research work for the topic chosen to get a clear view on the project. From the research done, the literature review is prepared, continued with experimental work, circuit design and simulation. The final work is analysis of the performance of new electronic ballast.

3.3 Tools and equipment used

The circuit schematics in this project will be simulated using:

- National Instrument Multisim 10

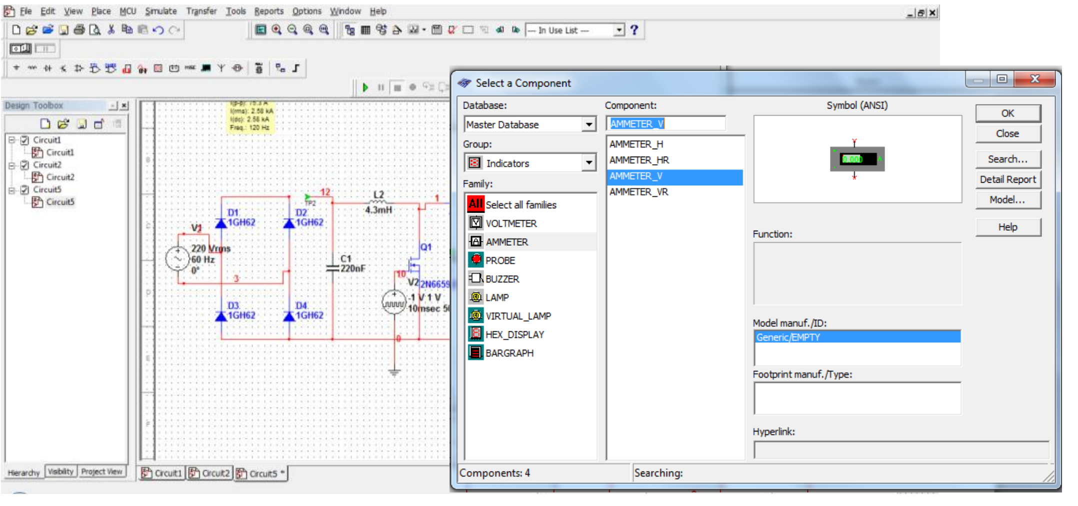

Figure 17: Multisim software

3.4 Simulation on proposed circuit

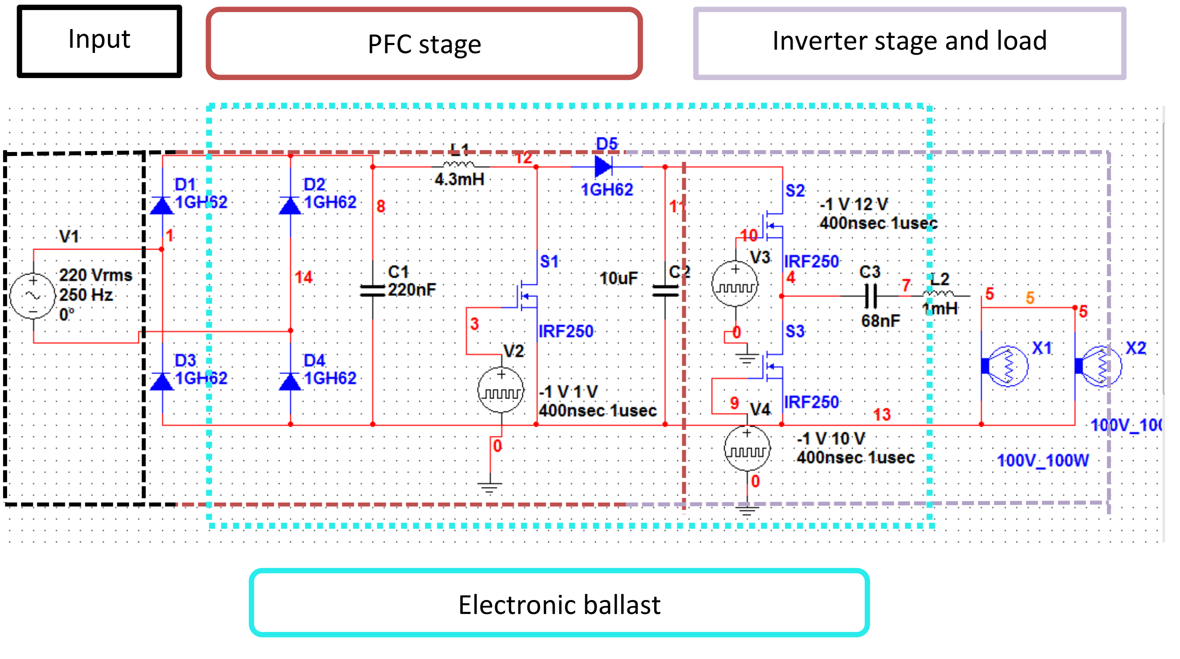

Figure 18: Schematic of electronic ballast

Figure 18 shows the three stage of ballast circuit. First is input stage that contains source V_1, the function of input stage is to provide voltage source to lamp. The second stage is power factor correction (PFC) stage. This stage contains full wave rectifier function as to change sine wave to full wave signal. In this stage also contains a boost converter that functions as to suppress the harmonic current due to the rectification to archive unity power factor. The third stage is inverter stage and load, to convert sinusoidal waveform to square waveform (pulse width modulation), and RLC load can be assumed as lamp load.

3.4.1 PFC stage

At this stage, when switch (S_1) is turn on, peak inductor current will be proportional to the instantaneous rectified line voltage. During the OFF-time of the switch, the inductor current decrease, and as soon as it reaches zero, the next cycle begins. The result of inductor voltage (V_{L1}) waveform can be seen at figure 13 in result and discussion part.

3.4.2 Inverter stage

Figure 10 shows the schematic of the resonant half bridge inverter stage. The inverter consists of the MOSFETs S_2 and $S_{3,}$ the resonant tank L_2, and a dc-blocking capacitor $C_{1.}$ C_2 function as a filterer noise from switching action of the half bridge. The noise of the inverter stage is small compared to the PFC stage.

3.4.3 Lamp load stage

Lamp load stage contains two lamps at 100W connected in parallel order, in order to reduce the cost of electronic ballast, two lamps was using one ballast to ON.

3.5 Gantt chart

Table 4: Project Gantt chart for FYP I

NO	DETAILS / WEEKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Topic selection and conformation	■	■ ★1												
2	Preliminary Research Work			■	★2										
3	Preparation of Extended Proposal				■	■	★3								
4	Experimental Work and circuit Design						■	■	★4						
5	Familiarization with ballast Theory						■	■	■	■	■	★5			
6	Proposal Defense							■	★6						
7	Circuit Design								■	■				★7	
8	simulation									■	■				★8
9	Analysis and Improvement of design										■	■			
10	Preparation of Interim Draft Report												■	■	
11	Improvement of Interim Report and submitting														■ ★9

■ **= process** ★ **= suggested milestone**

Table 4 shows the work schedule for this project in Final Year Project 1. It starts from topic selection and conformation with the supervisor in the first week until to the improvement of Interim report in week 14. Current progress is doing some simulation of electronic ballast circuit in Multisim for understanding the topic chosen.

Table 5: Project Gantt chart for FYP I

NO	DETAILS / WEEKS	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Analysis and improvement of design				1											
2	Performance Evaluation						2									
3	Preparation of Progress Report								3							
4	Analysis and Conclusion															
5	Preparation for Pre-SEDEX											4				
6	Preparation of Report															
7	Submission of Draft Report												5			
8	Submission of Dissertation													6		
9	Submission of Technical Paper														7	
10	Slide preparation and Oral Presentation														8	
11	Submission of Project Dissertation (Hard bound)															9

= process **= suggested milestone**

Table 5 show the work schedule for this project in Final Year Project 2. It will start from analysis and improvement of design in the first week until submission of project dissertation in week 15.

3.6 The Milestones

Figure 8 shows the milestones of the project. The project plan can be seen from the previous Gant chart and there are few milestones that have been set in order to ensure that the project will be completed within time and scope.

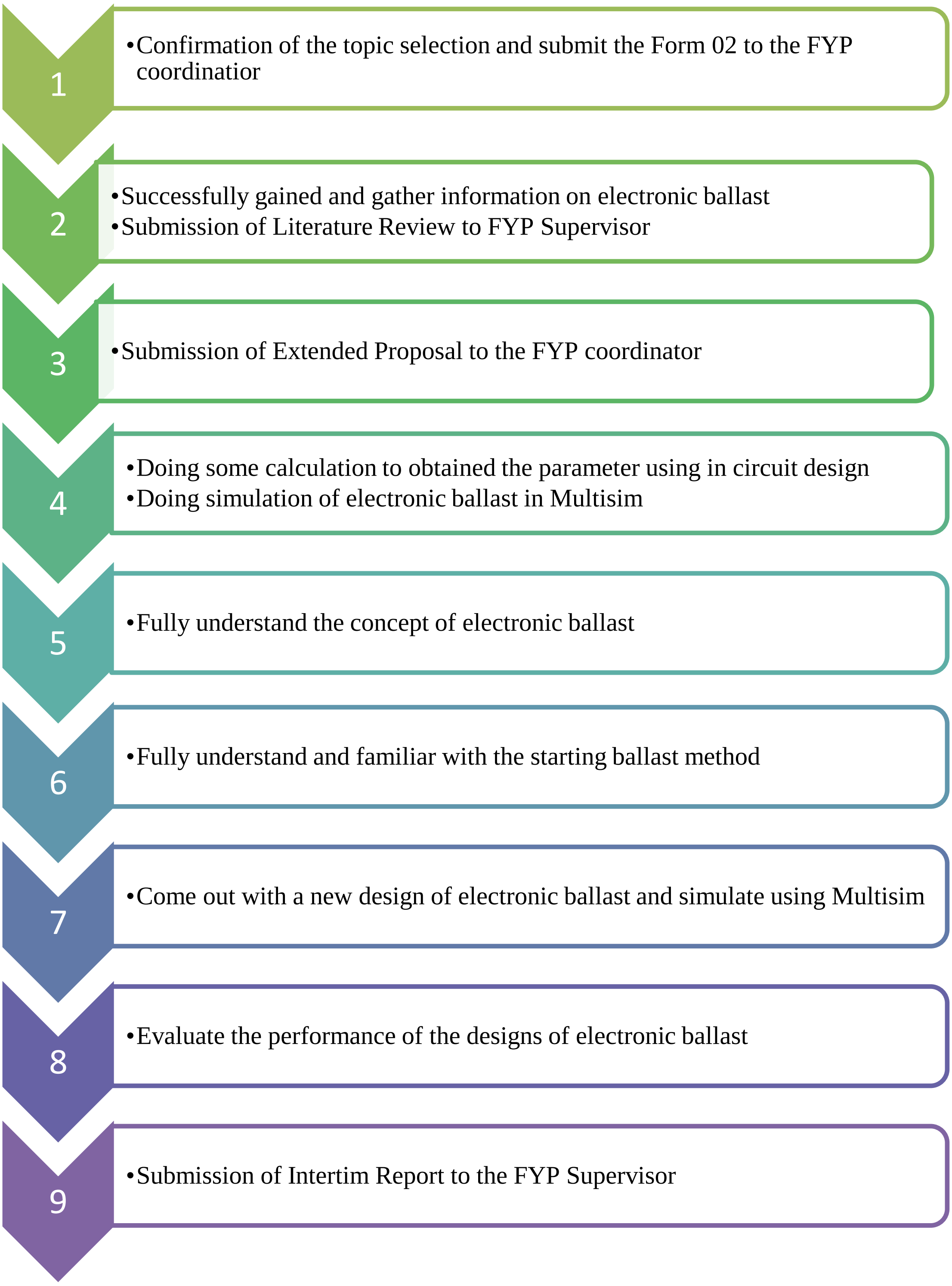

Figure 19: The Milestones for FYP 1

Figure 9 below shows the milestones planned for Final Year Project (FYP) II, which will starts in the next coming semester.

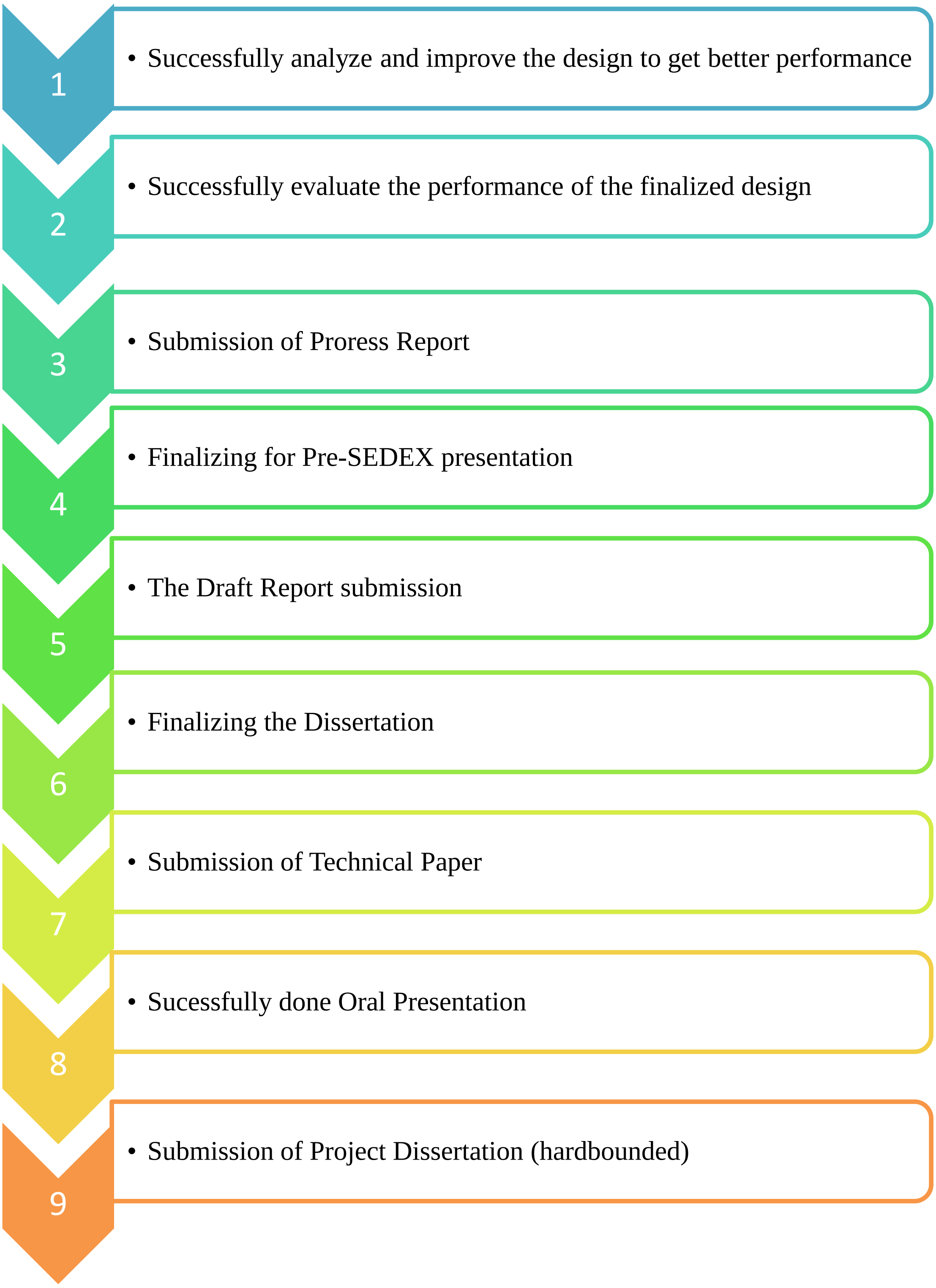

Figure 20: The Milestones for FYP 2

CHAPTER 4: SIMULATION RESULT

4.1 MOSFET switching

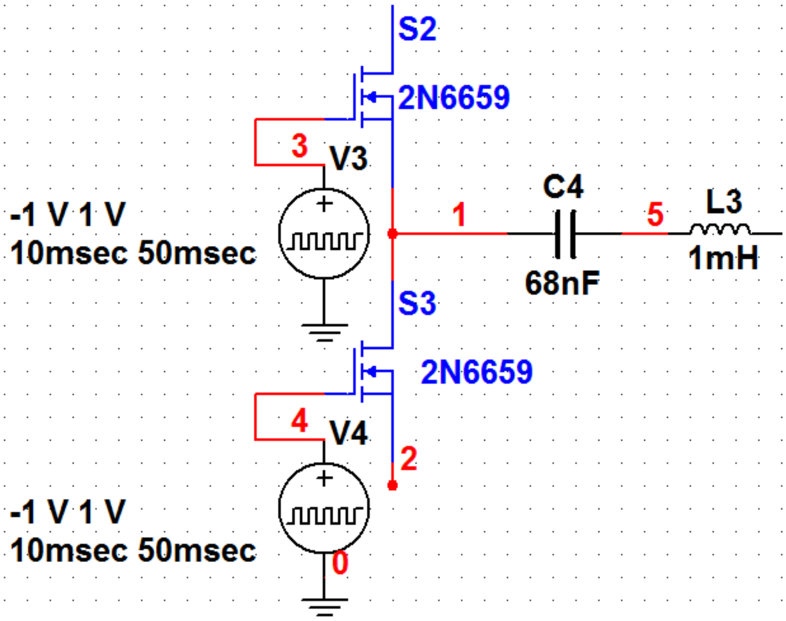

Figure 21: Synchronous switching using PWM

Figure 21 show there a two pulse applied to the circuit. The high side pulse drive the high side MOSFET and same with low side pulse drive the low side MOSFET. S2 act as high side MOSFET and S3 act as low side MOSFET. S2 and S2 must be ON simultaneously to avoid "shoot through" phenomenon [17] or cross conduction between two switches.

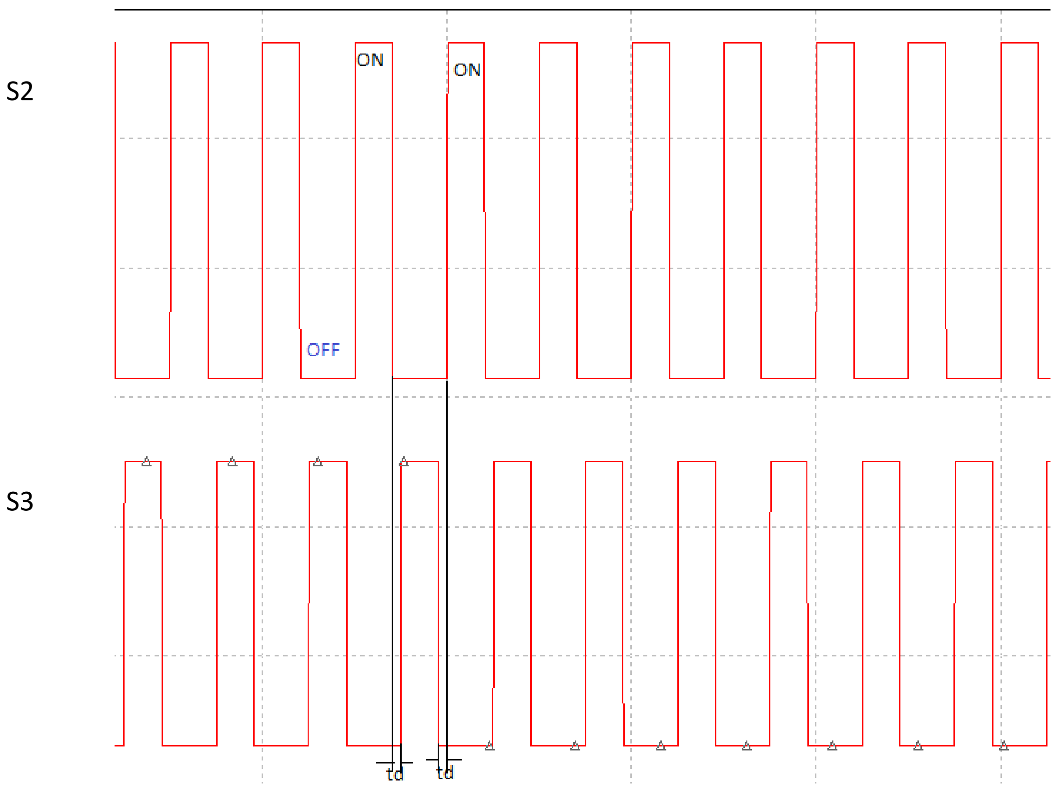

Figure 22: Waveform of MOSFET switching

S2= high side MOSFET ***S3= low side MOSFET***

Figure 22 shows the expected waveform from the electronic circuit from figure 10. S_H is high side MOSFET that we can see in figure 10 as S1. When S1 is ON, RL series impedance connects to the system, so the i_b (current at load) increase positively due to the DC voltage applied across resistor-inductor series branch.

When S1 is turn OFF, RL series impedance will cut OFF from the source an i_b will flow to the dependent voltage source C_3, so i_b will increase negatively due to the source of the energy is C_3 not from the main source.

Dead time delay, t_d

Dead time is used for pulse-width-modulation (PWM) controlled inverter control to avoid "short-circuit" or shoot through phenomenon of high-side and low-side power devices. The t_d is the time gap where no signal applied to the MOSFET. The t_d play important role since it related to the total losses.

4.2 PFC stage

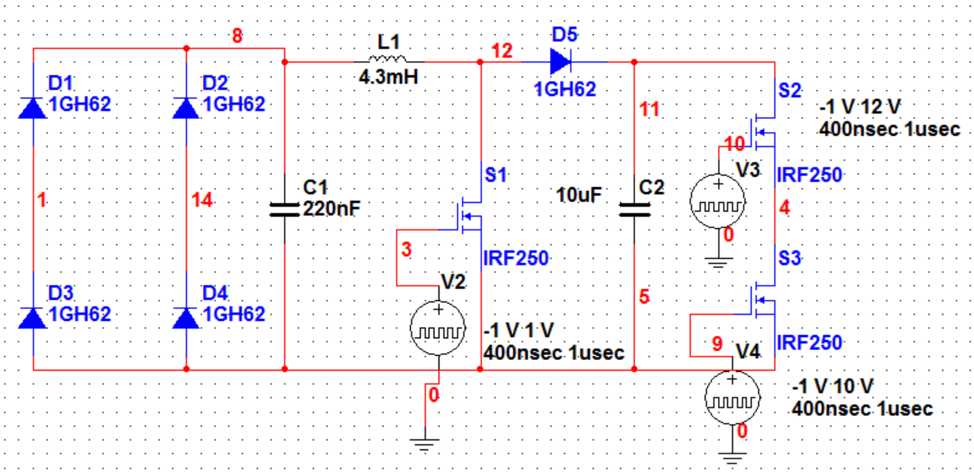

Figure 23: Power factor correction (PFC) stage

Figure 23 show that the PFC stage that function as to suppress harmonic current for unity power factor. In order to verify the design and wave signal [4], circuit in figure 4 was simulated using Multisim 10 software. The main parts of this circuit are the full bridge rectifier and boost converter. The parameters are chosen as$C1 = 220nF, C3 = 10\mu F, L2 = 4.3mH$. The diode has been chosen is type 1GH62 Toshiba.

Simulation result

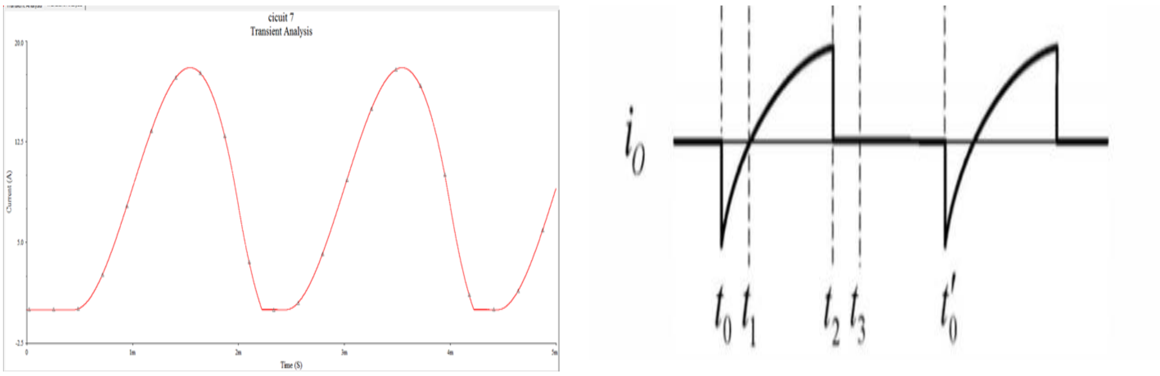

Figure 24: Simulation and expected result at PFC stage

Figure 24 shows that the simulation result on the left side and the expected result on the right side, the simulation result are slightly different from the expected result due to the component used in design circuit.

4.3 Lamp load stage

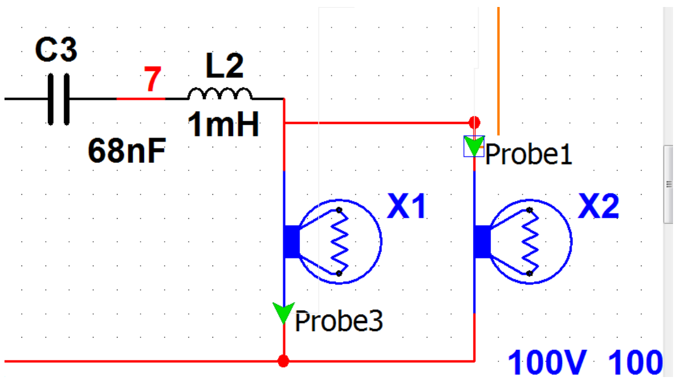

Figure 25: lamp load stage

Figure 25 shows that the topology of the load stage that have been design to verify the objective that is to used one electronic ballast with two lamps. Simulation have been perform using 100W lamp.

Simulation result

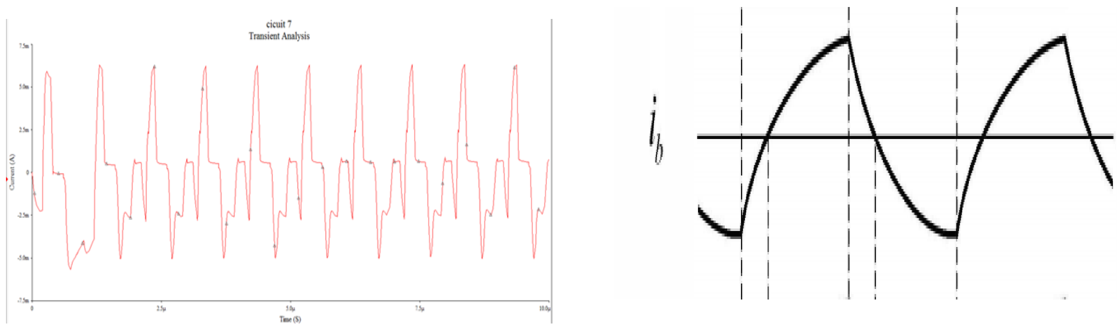

Figure 26: Simulation and expected current for 100W lamp [2]

Figure 26 shows the expected output current waveform on the right side and simulation result on the left side for 100W lamp.

CHAPTER 5: CONCLUSION

The project starts with research on type of ballast and starting method of ballast. Throughout the projects, several submissions of documentation took place. The Multisim software is used to implement this project. Electronic ballast will limit the current to the lamp, but in this project the current to the load is too low compared to the input current. The output result cannot be archived such as expected result due to the wrong simulation on the circuit.

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