

Faculty of Electrical and Electronic Engineering Technology



Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours

DEVELOPMENT OF HYBRID CONTROL OF DC-DC ZETA CONVERTER IN DISCONTINUOUS CONDUCTION MODE

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DECLARATION

I declare that this project report entitled "Development of Hybrid Control of DC- DC Zeta Converter in Discontinuous Conduction Mode" is the result of my own research except as cited in the references. The project report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



APPROVAL

I hereby declare that I have checked this project report and in my opinion, this project report is adequate in terms of scope and quality for the award of the degree of Bachelor of Electronics Engineering Technology (Industrial Electronics) with Honours.



DEDICATION

Personally, dedicated to my family and my supervisor who helped me to complete my final years report



ABSTRACT

Because of the fast growth of the Internet of Things (IoT), it is now necessary to have a reliable power source for the use of IoT devices. Any IoT gadget will require power to function. A gadget will always require a certain amount of voltage and current, whether it comes from a power outlet or a battery. Power is the result of these two variables (voltage and current). The device's energy is defined as the quantity of power utilised during a given time. Some of these devices consume small power and this led to discontinuous conduction mode (DCM) operation of a dc- dc converter. Therefore, a dc- dc zeta converter working in DCM is suggested, and the converter is stabilised using a hybrid control method based on the control Lyapunov function. A Lyapunov function is a scalar function defined on the phase space that may be used to verify an equilibrium point's stability. Circuit design and development, as well as microcontroller programming will be conducted for this project. The project expected that a stable output voltage will be produced although the changes at the input voltage and load.

ABSTRAK

Oleh kerana perkembangan Internet-of-Things (IoT) yang pesat pada masa kini, terdapat keperluan untuk mempunyai bekalan kuasa yang stabil untuk penggunaan peranti IoT. Mana-mana peranti IoT memerlukan elektrik untuk berfungsi. Sama ada dari soket kuasa atau bateri, peranti akan memerlukan voltan dan arus tertentu. Produk kedua (voltan dan arus) dipanggil kuasa. Kuasa yang digunakan dalam jangka masa tertentu adalah tenaga peranti. Sebilangan peranti ini menggunakan tenaga yang kecil dan ini membawa kepada operasi mod konduksi berterusan (DCM) penukar DC-DC. Oleh itu, dicadangkan penukar DC-DC Zeta yang beroperasi di DCM dan algoritma kawalan hibrid berdasarkan fungsi Lyapunov kawalan digunakan untuk menstabilkan penukar. Fungsi Lyapunov adalah fungsi skalar yang ditentukan pada ruang fasa, yang dapat digunakan untuk membuktikan kestabilan titik keseimbangan. Reka bentuk dan pengembangan litar, serta pengaturcaraan mikrokontroler akan dilakukan untuk projek ini. Projek ini menjangkakan voltan keluaran yang stabil akan dihasilkan walaupun perubahan pada voltan input dan beban.

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ة , تىكنىكل ملىسيا ملاك

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LIST OF SYMBOLS

 $\begin{array}{ccc} \Omega & & - & Ohm \\ ^{\circ}C & - & Celsius \end{array}$



LIST OF ABBREVIATIONS

V	-	Voltage
DC	-	Direct current
DCM	-	Discontinuous conduction module
PWM	-	Pulse- Width Modulation
Hz	-	Hertz



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CHAPTER 1

INTRODUCTION

1.1 Background

According to Hafez Sarkawi and Yoshito Ohta, Hybrid controller is presented that is applicable to dc–dc series converters and small signal approximation.[1] A variable switching frequency controller is also known as hybrid control.[1]

Nowadays, dc-dc converter is widely used as power supply in electronic systems. The dc output current of a switch-mode converter fluctuates in response to load variations. Pulse width modulation (PWM) is a frequently used method to control the output power of a power switch by altering the ON and OFF. The duty cycle is the ratio of ON time to switching period time. The PWM Zeta converter is a noninverting polarity step up/down converter that may be designed to generate low-ripple output current using either connected inductors or separate inductors.[2] The duty ratio range of the Zeta converter is wider than any other converter. Improved power factor, low input current distortion, low output current ripple, and a wide output-power range are all features of this converter.[2]

1.2 Problem Statement

The study of develop hybrid control for dc dc converters had been study by most of the researcher.[3][4] However, the project was only cover by using simulation environment. Hence, a hybrid control based on DC DC Zeta converter in DCM circuit design and development, as well as microcontroller programming should be study.

Lastly, if tOFF lasts long enough for the primary inductor to entirely discharge, the current in the inductor will be zero for a period of time. This is known as discontinuous conduction mode, because it causes both the diode and the MOSFET to be turned off (DCM).[5] So, dc-dc converters with zeta topology and control Lyapunov function should be study to ensures the output voltage is stable.

1.3 Project Objective

The main aim of this project is to propose a stable output voltage even there are changes of input voltage and load. Specifically, the objectives are as follows:

- a) To design a prototype of DC-DC Zeta converter
- b) To analysis the output voltage of the zeta converter
- 1.4 Scope of Project UNIVERSITI TEKNIKAL MALAYSIA MELAKA

The scope of this project are as follows:

- a) Design a dc- dc zeta topology converter with voltage and current sensors by using Proteus software.
- b) A prototype of zeta converter is constructed and tested.
- c) A hybrid control algorithm based on control Lyapunov function is used to stabilize the converter.
- d) Output voltage will be analysis.



Figure 1.1 Scope of works block diagram

1.5 Organization Structure

AALAYS/A

This report focuses on development of hybrid control of dc- dc zeta converter in discontinuous conduction mode. This report consists of five major sections: introduction, background study, methodology, results, and discussion, followed by a conclusion and future work.

Chapter 2 discusses the literature research introduction and other related studies to this project by different researchers that contain the basics of FPGA, solar panel, DC-DC converter, and the analysis fundamental.

Next, Chapter 3 discusses the methodology used to achieve the project objectives and scope of work. The specifications and flowcharts needed for the research summary to track the project flow will be studied. All data and results from the study are provided in chapter 4. All the observations and conclusions are discussed and observed in chapter 4. For the study of device performance, this chapter will present the findings in an appropriate diagram. Lastly, in Chapter 5, the results are concluded along with future job explanations.

All the observations and conclusions are discussed and observed in chapter 4. For the study of device performance, this chapter will present the findings in an appropriate diagram. Finally, in Chapter 5, the results are concluded along with future job explanations



CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter discussed all the information to this study of summarization from trustworthy resources in books or journals. Moreover, in this chapter, the conventional converter system's overview and the ideal method will be discussed. A briefly discuss the theories of dc- dc converter, PIC, and sensors will also be addressed in this chapter.



A dc-dc converter is frequently used as a power source in today's electronic systems. In current portable electronic devices and systems, a dc-dc converter is widespread. The UNVERSITEEXAMALANSIA MELAKA converter takes a constant voltage from the batteries and transforms it into a wide range of values depending on the charge state. The voltage may dip below the battery voltage at low charge levels, preventing the load from receiving steady voltage.[6] There for it needs to be regulated. Many studies have been conducted on the performance and control of direct voltage converters. A zeta converter is a dc-dc converter that can boost (step- up) and lower (step- down) input voltage levels and produce low ripple and positive output voltage.[7]

2.2.1.1 Buck Converter

A buck converter is used to lower (step- down) the output voltage level from a DC input voltage. It has simplicity and low-cost advantages against the other type of converter.[8] The buck converter's operation is controlled by a switch or MOSFET.[9] The Buck Converter circuit is shown in Figure 2.1



Figure 2.2 Buck Converter module

A lower DC output voltage than the input voltage is required in some SMPS circuits. This can be accomplished with the use of a tool called the Buck Converter. From a rectified AC source or any DC source, the DC input can be used. When electrical isolation between the switching circuit and the output is not required, this design is preferable. As long as the AC source and the rectifier are kept apart, it is possible to use a mains isolation transformer for the input.

The key region when utilising switching MOSFETs is the MOSFET switching losses must be balanced to avoid loss at peak efficiency, and the MOSFET thermal resistance must be minimised to achieve great circuit conductivity.[10]

The switching transistor that connects the Buck Converter's input and output is constantly flipping on and off at an extremely fast rate. In order to keep the load running when the switching transistor is not in operation, the circuit makes use of the energy stored in the inductor L during the transistor's on periods. The Flywheel Circuit, as it is frequently referred as, is responsible for the circuit's operation. This is due to the fact that the circuit functions similarly to a mechanical flywheel. When it receives regular pulses of energy, it maintains a smooth rotation (and hence produces energy) at a constant pace. This is due to the fact that the circuit functions similarly to a mechanical flywheel.

UNIVERSITI TEKNIKAL MALAYSIA MELAKA 2.2.1.2 Boost Converter

In a variety of applications, switched-mode power supply, such as DC to DC conversion, can be used to provide power. Although a direct current (DC) supply, such as a battery, is easily available in many circumstances, the voltage provided is insufficient for the system to which it is being supplied. Electric automobile motors, for example, require voltages in the range of 500V, which are significantly more than what can be produced by a single rechargeable battery. Although several batteries may be used, the additional weight and space required would be prohibitively expensive and impractical to transport. The

solution to this problem is to use fewer batteries while at the same time increase the available DC voltage to the required level by utilizing a boost converter to get the desired result. When it comes to batteries, whether large or tiny, there is another aspect to consider: their output voltage changes when the available charge is reduced. At some point, the battery voltage becomes insufficient to supply enough electricity to the circuit that is being powered by the battery. However, if the battery's low output level can be boosted to a usable level again with the help of a boost converter, the boost converter can help to extend the battery's useful life significantly.



Figure 2.4 Boost converter module

An ideal boost converter has high energy conversion efficiency; in theoretical, the output power must be the same as the input power to reach the lossless conversion. The conversion efficiency will be affected in practical due to the component selection and MOSFET switching frequency.[11]

2.2.1.3 Buck- Boost Converter

Buck-Boost converter is another type of switched-mode converter.[8][9] There will be two result of output voltage. It can be higher or lower than the input voltage.[9] The output voltage in buck mode is lower than the input voltage.[8] When boost mode, the output voltage will be higher than the input voltage.[8] However, during the buck-boost mode, the output voltage will be maintained that control by duty cycle or duty ratio. [8][9]



Figure 2.5 Buck- Boost converter circuit diagram



Figure 2.6 Buck- Boost converter module

2.2.1.4 SEPIC converter

The single-ended primary-inductor converter (SEPIC) is a DC/DC converter will produce an output voltage higher or lower than the input voltage like buck- boost conveter but it can also produce output voltage equal to the input voltage. The duty cycle of the control switch(S1) will regulates SEPICS's output.



Figure 2.8 SEPIC converter module

When the pulse is high and the MOSFET is turned on, the input voltage charges inductor 1 (L1) and capacitor 1 (C1) charges inductor 2 (L2). The output is maintained by capacitor 2 (C2) while the diode (D1) is turned off. The inductors output through the diode to the load and the capacitors are charged when the pulse is low/the MOSFET is off. The output will be higher if the pulse is low for a bigger proportion of the time (duty cycle). This is due to the

fact that the longer time for the inductors charge, the higher the voltage. The capacitors will not be able to charge if the pulse lasts too long, and the converter will fail. [12]

2.2.1.5 Zeta converter

A zeta converter is also known as inverting SEPIC converter that can boost and lower input voltage levels without inverting the polarities. The circuit consists of two inductors L1 and L2, two capacitors C1 and C2, a diode D, a dc voltage source VIN, a resistive load R and a MOSFET (switch S).



For PWM Zeta converter, the third time interval of the operation cycle is nonzero in a discontinuous conduction mode (DCM), not that the inductor current is discontinuous. PWM Zeta converters with DCM can use coupled inductor approaches to provide low-ripple output current. [2]

2.2.2 Arduino

Arduino is a programmable board that is free source. It's incredibly simple to use. It includes an Integrated Development Environment (IDE) for writing and running programmes, which are referred to as sketches in Arduino, as well as a microcontroller. [13]



Figure 2.10 Classification of Arduino board

2.2.2.1 Arduino UNO



Invented by Leonardo da Vinci, Arduino Uno is a single-board computer built around the ATmega328P microprocessor. With 14 digital input/output pins (of which six are PWM outputs), six analogue inputs, a 16 MHz ceramic resonator (CSTCE16M0V53-R0), a USB connection, a power jack, an ICSP header, and a reset button, it is a versatile board. This kit has all of the components necessary to get started with the microcontroller; all you have to do is connect it to a computer via a USB cable or power it using an AC/Dc adapter or a battery. You may play about with your Uno without being concerned about making a mistake; if something goes wrong, you can just replace the chip for a few dollars and start again with a fresh game.

"Uno" means "one" in Italian and was chosen to commemorate the launching of the Arduino Software Development Environment (IDE) 1.0. The Uno board and Arduino Software (IDE) version 1.0 were the reference versions of Arduino, which have since evolved into newer releases. The Arduino Uno board is the first of a series of USB Arduino boards and serves as the platform's standard model; for a complete list of current, previous, and obsolete versions, see the Arduino index of boards.

2.2.2.2 Arduino Mega



The Arduino Mega 2560 is a board based on the Atmega2560 microcontroller. It features 54 digital input/output pins (15 of which are PWM outputs), 16 analogue inputs, four UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It includes everything you need to get started with the microcontroller; simply connect it to a computer through a USB wire or power it with an AC-to-DC adapter or battery. The Mega 2560 board is compatible with the majority of shields made for the Uno, Duemilanove, and Diecimila boards.

2.2.2.3 Arduino DUE



Figure 2.13 Arduino DUE

The Arduino Due is an ARM Cortex-M3 microcontroller board based on the Atmel SAM3X8E SAM3X8E SAM3X8E SAM3X8E SAM3X8E SAM3X8E SAM3X8E SAM3X8 It is the first Arduino board to feature a microprocessor with a 32-bit ARM core. It features 54 digital input/output pins (12 of which can be used as PWM outputs), 12 analogue inputs, four UARTs (hardware serial ports), an 84 MHz clock, a USB OTG connection, two DACs (digital to analogue), two TWI, a power jack, an SPI header, a JTAG header, a reset button, and an erase button.

The board includes everything necessary to support the microcontroller; all you need to do is connect it to a computer via a micro-USB connection or power it with an AC-to-DC adapter or battery. The Due is compatible with all Arduino shields that operate at 3.3V and adhere to the Arduino pinout version 1.0.

2.2.3 COMPONENTS

2.2.3.1 IRF530 MOSFET



Figure 2.14 IRF 530 MOSFET

In this case, the power field effect transistors have an N-Channel enhancement mode silicon gate, and the transistors have an N-Channel enhancement mode silicon gate. Power MOSFETs with a high level of energy resistance, which are used in the breakdown avalanche mode of operation, are used in this application. In addition to switching regulators and switching converters, motor drivers, relay drivers, and drivers for high power bipolar switching transistors that require a high rate of operation and low gate drive power, all of these power MOSFETs can be utilised in other applications, such as these. These types of circuits can be used right away, even in integrated circuits.

2.2.3.2 FAN7390MX GATE DRIVER



Figure 2.15 FAN7390MX

If required to drive fast MOSFETs and IGBTs that can work at up to 600 V, the FAN7390 is the right thing for you. It's a single chip that can do both. It has a buffered output stage with all NMOS transistors that are made for high pulse current driving and low crossconduction. The high-voltage process and common-mode noise-cancelling procedures used by ON Semiconductor ensure that the high-side driver continues to function even when there is a lot of noise in the dv/dt line. An upgraded level shift circuit allows the high-side gate driver to operate up to VS = 9.8 V for VBS = 15 V when using a level shift circuit. When the voltages of VDD and VBS fall below a predetermined level, the UVLO circuit prevents things from going wrong and causing damage. Because it can withstand a large amount of current and has a low voltage drop when turned on, this device is well suited for applications such as PDP sustain pulse driver, motor driver, switching power supply, and high-power DC–DC converters.



Figure 2.16 INA 225

The INA225 is a voltage-output, current-sense amplifier that senses drops across currentsensing resistors at common-mode voltages that can range from 0 V to 36 V, no matter what the supply voltage is. It doesn't matter what the supply voltage is. The device is a bidirectional, current-shunt monitor that lets an outside source be used to measure the amount of current flowing in both directions across a current-sensing resistor. The two gain-select terminals (GS0 and GS1) can be used to set up 4 gains mode. If you want to measure current with a maximum drop across the shunt of 10 mV of full-scale, you can do

that thanks to a low-offset design, zero drift, and precise gain values. Using a single +2.7-V to +36-V power source, the device can only draw 350 A of power. The device can run at temperatures from -40°C to +125°C and comes in an MSOP-8 package.

2.2.3.3 INA 146 Voltage sensor



Figure 2.17 INA 146

The INA146 is a precision difference amplifier that can be used to precisely attenuate and reject high differential voltages in order to keep signal processing voltage levels the same as they are in other places. In addition, the high-voltage ability protects the inputs. The INA146's input common-mode range is bigger than both supply rails, so it can be used in both single and dual supply applications.

A laser is used to trim precision resistors on the chip to make sure they have strong commonmode rejection and the correct gain. These resistors have very good TCR tracking, which means that they stay very accurate over a wide temperature range. In this case, a 10:1 difference amplifier has a gain of 0.1V/V when used as a buffer. This arrangement lets you measure voltages up to 100V. In this case, an external resistor pair can be used to set gains greater than 0.1V/V without having to change the common-mode input

range.

There is a surface-mount package for the INA146 that can go from -40°C to +85»°C.

2.3 Software

2.3.1 Arduino IDE



Figure 2.18 example coding in Arduino IDE

The IDE stands for Integrated Development Environment, which is what you'll find on the Arduino board. Arduino.cc has released an official version of this software. This programme is compatible with the vast majority of Arduino modules. Linux, Mac OS X, and Windows may all use it. The programming languages C and C++ can be used to develop it. Programming languages like Java and open-source tools like Processing are used in the environment.

2.

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2.3.2 MATLAB UNIVERSITI TEKNIKAL MALAYSIA MELAKA

and_ty		 Worksp 	bace		
1	a = 1; b = 'hello':	:: Name	:: Value	:: Size	:: Class
2	c = "hello";	🔣 a	1	1×1	double
4	d = [1 2 3]; % row vector	🔡 ans	2	1×1	double
5	e = [1;2;3]; % column vector	b	'hello'	1×5	char
6	f = [1 2 3; 4 5 6];	str C	"hello"	1×1	string
7	<pre>g = ["hello" "yes"];</pre>	d 🔣	[1,2,3]	1×3	double
8	h = {'hello' 34 [1 2 3];'yes' 45 [4 5 66]}; % cell array	e	[1;2;3]	3×1	double
9	<pre>i = struct('name','frank','gpa',3.9,'grade',3);</pre>	f f	[1,2,3;4,5,6]	2×3	double
0	j(1,2,2) = i;	str g	1×2 string	1×2	string
1	j(1,1,2) = i;	() h	2×3 cell	2×3	cell
2		i i	1×1 struct	1×1	struct
3	a <mark>+</mark> 1	j	1×2 struct	1×2×2	struct
4					

Figure 2.19 example of MATLAB

MATLAB is a high-performance programming language for the design and analysis of complex computer systems. Calculation, visualisation, and programming are all integrated into a simple user interface with well-known terminology for problems and answers. The MATLAB language, a matrix-based language, is at the heart of MATLAB and gives the most natural explanation of computer mathematics.

	MICROCONTROLLER	FLASH	SRAM	PIN	VOLTAGE
		MEMORY			
UNO	8-bit ATmega328P 16 MHz	32 KB	2 KB	14 I/O, 6 analog inputs	7-12 V input, 5 V output
MEGA	8-bit ATmega2560 16 MHz	256 KB	8 KB	54 I/O, 16 analog inputs	7-12 V input, 5 V output
DUE	32-bit AT91SAM3X8E 84 MHz	512 KB	96 KB بېنې نيد	54 I/O, 12 analog inputs	7-12 V input, 3 V output
	UNIVERSITI TEK	NIKAL MA	LAYSIA	MELAK	A

Table 2-1 shows the specification of Arduino

2.4 Summary

The literature review's contribution is to explain the analysis of the dc- dc converter and provide the controller used in the system. The hardware and methods used in the project will also be discussed in this chapter. The best software and hardware to be used in Arduino software because it is low-cost standalone hardware and software.



CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter aims to describe the methodology of this project. A few steps are used to achieve the objective of the project in the project methodology. The hardware and methods used in the project will also be discussed in this chapter. Moreover, the flowchart, hardware and software implementation and block diagram will be shown in this chapter also.

3.2 Flowchart

In the beginning of this project, the flow will start by identify the component characteristic and parameter to decide the next step of the design will going based on the parameter. Once the parameter had decided, the design of the dc- dc zeta converter circuit will explain chapter 3.4. First, identifying components characteristic will be started. Next, a dc- dc zeta converter will be design with INA225 (current sensor) and INA146 (voltage sensor). Even when the input voltages and load fluctuate, a steady output voltage is still provided. The values will be display at LCD. The flowchart of the project shown in



Figure 3.1 Project flowchart

3.3 Block diagram

In the beginning of this project, the flow will start by identify the component characteristic and parameter to decide the next step of the design will going based on the parameter. Once the parameter had decided, the design of the dc- dc zeta converter circuit will be explained on Chapter 3.4. From the design of dc- dc zeta converter circuit, the voltage and current sensor values need to obtain by INA 146 and INA 225. A pulse- width modulation with generated by Arduino DUE to the gate driver FAN390MX to control the MOSFET IRF530. Before that, another buck- boost converter will be used to activate the gate driver at least 15v. After that, voltage sensor INA 146 and current sensor 225 will detect the value of voltage and current. The values will then send to Arduino DUE and program to get a stable and low ripple output.



Figure 3.2 Block digram of the system

3.4 Zeta Circuit

A zeta converter is a type of DC voltage converter used in electronics that may convert a positive DC supply voltage to either a higher or lower positive DC output voltage. This converter is utilized in electronic circuit power supply modules. In switched-mode power supply, modified Zeta converter types with galvanic isolation are utilized for active reactive power adjustment.



3.5 Component Characteristic

In this project, the main component that used is Arduino DUE, with 16Mhz crystal oscillator and 32-bit ARM core. From the frequency and using formula (1) the Time for one clock cycle was 15us.

$$f = \frac{1}{T}$$

Equation 1

Once the parameter of the clock cycle was obtained, the Arduino DUE will process the output PWM signal send through FAN7390MX driver to operate MOSFET IRF530 as output switch. The reason to use the MOSFET driver is because the PWM signal with high frequency from the Arduino DUE will be relative low to operate the MOSFET and will cause the MOSFET not functioning.

The MOSFET required a 20V at Vgs and directly affect the Rds with the range of $0.160\Omega m\Omega$ or 20V at Vgs and Rds < 0.14Ω which is relatively low resistance and can get higher performance in the buck-boost converter.

The INA146 current sensor was yet another important component in this project's development. When applied to common-mode voltages ranging from 0V to 36V, the INA 225 detects voltage variations across current- detecting resisters, regardless of the power supply voltage applied to the amplifier's output. An external reference is used to measure the current flowing in both directions across a current- detecting resistor in this device, which is referred to as a bidirectional current- shunt monitor.

3.6 Software



Figure 3.3 Block diagram Arduino IDE Development

Arduino is a microcontroller that is open-source. Using a USB cord, it may be modified and loaded into the microcontroller. Arduino is a low-cost prototyping platform using a single CPU. The application is written in a standard programming language akin to C/C++. Arduino comes with a bootloader that runs on the board to run the software. The Arduino was chosen for this project because it offers several benefits over other microcontrollers such as the PIC.

3.7 Gantt Chart



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3.8 Summary

This chapter discussed the configuration of dc- dc zeta converter and hybrid control algorithm based on control Lyapunov function.



CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

This chapter will provide all the results from this project which includes the simulation and hardware implementation. The analysis of efficiency of solar system will included in this chapter.

4.2 Zeta converter circuit

As mention in chapter 3, the zeta converter circuit will be discover from the result of simulation and also the hardware develop.

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4.3 **PWM signal simulation**

In the test, the Arduino IDE had been simulated the PWM signal to gate driver FAN7390MX had shown in Figure 4.1 (Placeholder1). The PWM is set to 3.3V because, unlike most Arduino boards, the Arduino Due board operates at 3.3V voltage. The I/O pins can withstand a maximum voltage of 3.3V at any given time. Applying voltages to any I/O pin that are higher than 3.3V may cause harm to the board.

💿 test | Arduino 1.8.16

File Edit Sketch Tools Help



Figure 4.1 coding for PWM signal.

In this coding, there will be 5us at high state and 10us at low state. Therefore, around 33.33%



Figure 4.2 Simulation PWM signal



4.4 Output Waveform from gate driver FAN390MX

Figure 4.3 Output waveform from pin 4 LO(low output)



Figure 4.4 Output waveform from pin 7 HO(high output)

For the output waveform, the output from pin 7 HO(high output) cannot get the value but pin4 LO(low output) can get nearly 5V by receiving 3.3V PWM signal from Arduino DUE.

4.5 Output waveform from load

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170 Tume			
. Vertical			Time/Div
🚽 🖗 Maximum	a se acceso a	i era no forme an forme an era no forme a no forme a no forme a no forme a	1,000ms v
🗋 🗣 Minimum			
Top	E E E E E		Porma:
- 🖸 🛛 Base			Y-T V
- 🗌 🖗 Middle			
- Amelituda			Vertical
Mean	at the to be	ดกมาให้สิ่งในกลางที่ไปที่มหาไขโทยก็ไข้ไปของไปไม่มาไปที่มี <u>เชื่อเป็น โกยใน กลางที่ได้เป็นไข้ไปที่มา</u> สน้ำไปไป	
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- Duty Cycle	Output		
🗌 🌳 + Pulse Width	B CH2		
- Pulse Width	Maximum	11.9mV	
	+ Duty Cycle	1.330MTz 1.2%	
	. Dury Cycle	THE CO.	

Figure 4.5 Output waveform from load

For the output waveform from load, the waveform did not gain perfectly due to the noise and also the from the ho (high output). Since there is a small voltage across ho (high output), therefore, the output waveform from load will not appear as well.

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4.6 Hardware





Figure 4.7 Test run for first PCB design





Figure 4.9 Second PCB design (bottom view)



Figure 4.10 Test run for second PCB

Figure 4.11 Output from drive gate

For the hardware part, first PCB was designed but sadly the driver gate did not function. There is a little of output voltage from pin7 ho (high output) from FAN7390MX. After discussing with supervisor, the second PCB was designed. There were a lot of enhancements compare to previous PCB. The second PCB is more smaller and put in orderly. The copper line is wider than first PCB. The same thing happend again after PWM signal is sent from Arduino DUE to zeta circuit. There is no output from the pin7 ho (high output) from FAN7390MX. The digital oscilloscope is used to measure the output from pin7 ho (high output) from FAN7390MX but still get a small output voltage.

After tried few times with the prototype, a simple circuit was constructed as Figure 4.11. The reason of construct a simple circuit on breadboard is to test the gate driver is defect or functional. In the end, the gate driver can normal function. As a result, a boldly speculate that the issue is with the prototype.

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4.7 Chapter summary

This chapter discussed the result had been obtained with the methodology that had been proposed. The first part of this chapter discussed about the result of zeta converter circuit. The control Lyapunov function is used to control the DC- DC converter by compare the different voltage and current. The Arduino DUE generate PWM signal to control MOSFET be turning ON and OFF. Arduino DUE also generate a new power source connect to buckboost converter to active the gate driver.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

In this chapter, the conclusion of the overall project on achieving the objective and the overall working principle of the prototype will be discussed. At the end of this chapter, the future works for the project will be given for future improvement.

5.1 Conclusion

To conclude the overall of project, one of the objectives had been achieved. The prototype of DC- DC zeta converter had successfully developed by using Arduino DUE. Arduino DUE had sent 3.3V, 33% duty cycle PWM signal to DC- DC zeta converter. Unfortunately, a stable output did not get from this project.

5.2 Recommendation

There are several recommendations for improve the design of zeta converter. Firstly, the gate driver can be replace by other model. The reason FAN7390MX is used because it can accept a 3.3V input PWM signal. The next recommendation for this project is the design for PCB trace width (copper line) should be wider. The thicker traces have been optimized for current carrying capacity and general power delivery to lower level components.

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APPENDICES

Appendix A Work progress

















Appendix B Datasheet

High-Current, High & Low-Side, Gate-Drive IC

FAN7390

Description

The FAN7390 is a monolithic high- and low-side gate-drive IC, which can drive high speed MOSFETs and IGBTs that operate up to +600 V. It has a buffered output stage with all NMOS transistors designed for high pulse current driving capability and minimum cross-conduction.

ON Semiconductor's high-voltage process and common-mode noise canceling techniques provide stable operation of the high-side driver under high dv/dt noise circumstances. An advanced level shift circuit offers high-side gate driver operation up to VS = -9.8 V (typical) for VBS = 15 V.

The UVLO circuit prevents malfunction when VDD and VBS are lower than the specified threshold voltage.

The high current and low output voltage drop feature make this device suitable for the PDP sustain pulse driver, motor driver, switching power supply, and high- power DC-DC converter applications.

Features

- Floating Channels for Bootstrap Operation to +600 V
- Typically 4.5 A / 4.5 A Sourcing / Sinking Current Driving Capability
- Common-Mode dv/dt Noise-Canceling Circuit
- Built-in Under-Voltage Lockout for Both Channels
- Matched Propagation Delay for Both Channels
- · Logic (Vss) and Power (COM) Ground ±7 V Offset
- 3.3 V and 5 V Input Logic Compatible
- Output In-Phase with Input
- This is a Pb-Free Device

Applications

- UNIVERSITI TEKNIKAL MALAYSIA MELAKA PDP Sustain Driver
- HID Lamp Ballast
- SMPS
- Motor Driver



EAN7	390MX	FAN7390M1X
7390, FAN73	= Device Co	de
Â	= Assembly = = Wafer Lot I	Site Number
YW	= Assembly :	Start Week
8.Z	= Assembly I	Plant Code
8.3	= 3-Digit Del	te Code
8K	= 2-Digits Lo	t Run Traceability Code

ORDERING INFORMATION

See detailed ordering and shipping information on page 12 of this data sheet. 000

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Data Sheet

February 2002

IRF530

14A, 100V, 0.160 Ohm, N-Channel Power MOSFETs

These are N-Channel enhancement mode silicon gate power field effect transistors. They are advanced power MOSFETs designed, tested, and guaranteed to withstand a specified level of energy in the breakdown avalanche mode of operation. All of these power MOSFETs are designed for applications such as switching regulators, switching convertors, motor drivers, relay drivers, and drivers for high power bipolar switching transistors requiring high speed and low gate drive power. These types can be operated directly from integrated circuits.

Formerly developmental type TA17411.

Ordering Information

Features

- 14A, 100V
- rDS(ON) = 0.160Ω
- · Single Pulse Avalanche Energy Rated
- SOA is Power Dissipation Limited
- Nanosecond Switching Speeds
- Linear Transfer Characteristics
- High Input Impedance
- Related Literature
 - TB334 "Guidelines for Soldering Surface Mount Components to PC Boards"

Symbol



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High-Voltage, Programmable Gain DIFFERENCE AMPLIFIER

FEATURES

- HIGH COMMON-MODE VOLTAGE: +40V at V₈ = +5V ±100V at V₈ = ±15V
- DIFFERENTIAL GAIN = 0.1V/V TO 100V/V: Set with External Resistors
- LOW QUIESCENT CURRENT: 570µA
- WIDE SUPPLY RANGE: Single Supply: 4.5V to 36V Dual Supplies: ±2.25V to ±18V
- LOW GAIN ERROR: 0.025%
- HIGH CMR: 80dB
- SO-8 PACKAGE

APPLICATIONS

CURRENT SHUNT MEASUREMENTS

- SENSOR AMPLIFIER
- SYNCHRONOUS DEMODULATOR
- CURRENT AND DIFFERENTIAL LINE RECEIVER
- VOLTAGE-CONTROLLED CURRENT

DESCRIPTION

The INA146 is a precision difference amplifier that can be used to accurately attenuate high differential voltages and reject high common-mode voltages for compatibility with common signal processing voltage levels. High-voltage capability also affords inherent input protection. The input common-mode range extends beyond both supply rails, making the INA146 well-suited for both single and dual supply applications

On-chip precision resistors are laser-trimmed to achieve accurate gain and high common-mode rejection. Excellent TCR tracking of these resistors assures continued high precision over temperature.

A 10:1 difference amplifier provides 0.1V/V gain when the output amplifier is used as a unity-gain buffer. In this configuration, input voltages up to ±100V can be measured. Gains greater than 0.1V/V can be set with an external resistor pair without affecting the common-mode input range.

The INA146 is available in the SO-8 surface-mount package specified for the extended industrial temperature range, -40°C to +85°C.





INA225

SBOS812A - FEBRUARY 2014 - REVISED MARCH 2014 INA225 36-V, Programmable-Gain, Voltage-Output, Bidirectional, Zero-Drift Series,

Current-Shunt Monitor

1 Features

- Wide Common-Mode Range: 0 V to 36 V
- Offset Voltage: ±150 µV (Max, All Gains)
- Offset Voltage Drift: 0.5 µV/*C (Max)
- Gain Accuracy, Over Temperature (Max):
 - 25 V/V, 50 V/V: ±0.15%
 - 100 V/V: ±0.2%
 - 200 V/V: ±0.3%
 - 10-ppm/*C Gain Drift
- 250-kHz Bandwidth (Gain = 25 V/V)
- Programmable Gains:
 - G1 25 V/V
 - G2 50 V/V
 - G3 100 V/V
 - G4 = 200 V/V
- Quiescent Current: 350 µA (Max)
- Package: MSOP-8

2 Applications

- Computers

3 Description

The INA225 is a voltage-output, current-sense amplifier that senses drops across current-sensing resistors at common-mode voltages that can vary from 0 V to 36 V, independent of the supply voltage. The device is a bidirectional, current-shunt monitor that allows an external reference to be used to measure current flowing in both directions across a current-sensing resistor.

Four discrete gain levels are selectable using the two gain-select terminals (GSD and GS1) to program gains of 25 V/V, 50 V/V, 100 V/V, and 200 V/V. The low-offset, zero-drift architecture and precision gain values enable current-sensing with maximum drops across the shunt as low as 10 mV of full-scale while maintaining very high accuracy measurements over the entire operating temperature range.

The device operates from a single +2.7-V to +36-V power supply, drawing a maximum of 350 µA of supply current. The device is specified over the extended operating temperature range (-40°C to +125°C), and is offered in an MSOP-8 package.

