MULTIPURPOSE MOTOR DRIVE SYSTEM FOR SMALL MACHINE

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Faculty of Electronic and Computer Engineering

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"I hereby declare that this report is the result of my own work except for quotes as cited in the references."

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"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of the scope and quality for the award of Bachelor of Electronic Engineering (Industrial Electronics) With Honours."

Signature : .....

Supervisor's Name : FARID ARAFAT BIN AZIDIN

Date : 12/05/08

To my beloved mom, dad, my supervisor and also my friends that had helped me to finish this thesis.

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ABSTRACT

Before this, AC (alternate current) motor is usually driven by a separated drive system, where single phase motor is driven by single phase drive system and 3-phase ac motor is driven by 3-phase drive system. This project is to develop a multipurpose motor drive system that capable to drive both single and 3-phase AC (alternate current) motor. The main component for the drive system is power integrated module IRAMS. IRAMS is consists of an array of 6 IGBT to form the 3 phase inverters. The 3 phase inverter is formed by connecting 3 single phase half-bridge inverters in parallel and controlled by PWM signal. This inverter converts DC source to variable 3 phase AC source. The AC source is then to be fed to the drive system as a controller for the motor. The methodology to achieve the objective of the project is consists of 4 phase which are project planning, literature review, hardware design and performance test. By following the methodology, this project is expected able to provide the drive system required.

ABSTRAK

Sebelum ini motor AU (arus ulang alik) hanya menggunakan satu sistem pemacu dimana motor satu fasa menggunakan sistem pemacu satu fasa dan motor 3 fasa menggunakan sistem pemacu 3 fasa. Projek ini bertujuan untuk menghasilkan satu sistem pemacu motor yang mampu untuk mengawal motor arus ulang-alik satu fasa dan 3 fasa. Komponen utama untuk sistem pemacu ini adalah 'power integrated module IRAMS. IRAMS ini terdiri daripada satu susunan 6 IGBT untuk menghasilkan satu pengubah songsang 3 fasa. Pengubah songsang ini terdiri daripada 3 pengubah sonsang satu fasa yang bersambung secara selari dan dikawal oleh isyarat PWM. Pengubah songsang ini menukarkan arus terus kepada arus ulang alik 3 fasa. Keluaran daripada IRAMS ini kemudianya di sambung kepada sistem pemacu tersebut sebagai pengawal kepada motor tersebut. Metodologi yang digunakan untuk mencapai objektif projek ini merangkumi 4 fasa; perancangan projek, kajian, rekabentuk, dan pengujian. Dengan mengikuti metodologi tersebut, projek ini dijangka mampu menghasilkan system pemacu motor yang pelbagai fungsi.

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AC	Alternate Current
DC	Direct Current
PWM	Pulse Width Modulation
IPM	Integrated Power Module
IR	International Rectifier
NPT	Non Punch Through
IC	Integrated Circuit
Dbs	Bootstrap Diodes
Cbs	Bootstrap Capacitor
Fsw	Switching Frequency
RMS	Root Mean Square

CHAPTER 1

INTRODUCTION

This chapter will make an introduction about the project, which will cover the background of the project, overview of the main component, project objective, problem statement, scope of work, and the methodology of the project.

1.1. PROJECT INTRODUCTION

What is multipurpose motor drive system?

Multipurpose motor drive system is a drive system that capable of driving both single phase motor and three phase motor. In this design, these features; are combined into one circuit.

- Single phase motor drive system.
- Three phase motor drive system.

1.2. BACKGROUND

Three phase AC motors have been in operation worldwide for decades. They offer relative simplicity of construction, low maintenance, and high efficiencies. This type of motor is quite hard to control and with the addition of a microcontroller (IRAMS) as a control device, three phase motor can be used for a wide range of application such as washing-machine, air conditioners and others. The AC induction motor is widely used in a number of variable-speed or torque control applications.

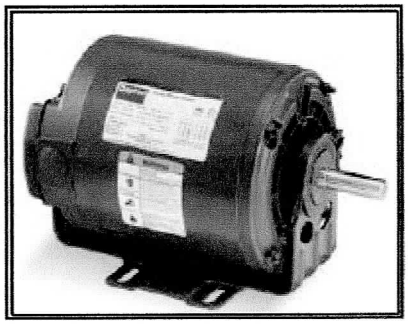

Figure 1.1 Three phase AC motor

AC Motor Drive

The AC motor drive not only needs to create AC waveforms for three phases but also control the amplitude and the frequency of these AC waveforms. Improvement of power electronics devices and microcontroller unit has made implementation of AC motor drive hardware simpler and more cost effective.

Since the normal line frequency and voltage are fixed, AC motor drives are based on the fact that variable-frequency and variable-voltage AC waveform can be generated. The most common type of drive is the converter-inverter structure.

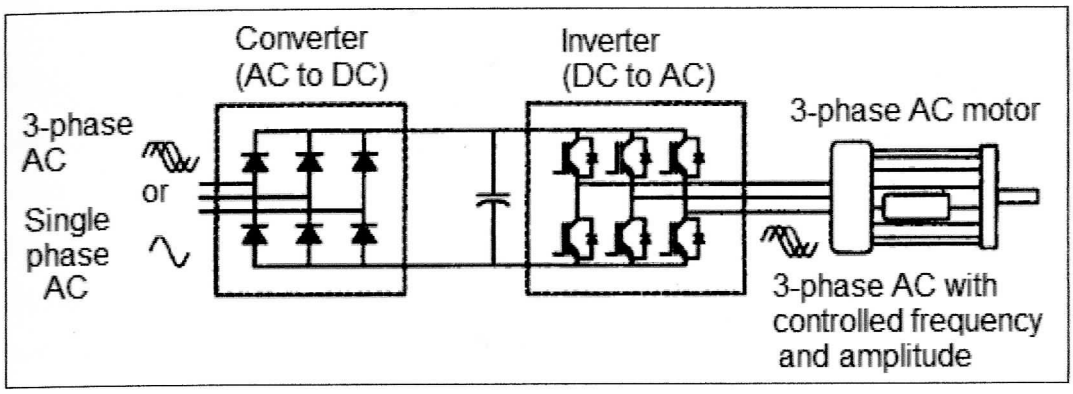

Figure 1.2 Three phase AC motor drive.

The converter converts the AC line into DC, while the inverter develops the variable-frequency and variable-voltage AC from the DC with the help of the microcontroller. Because of the inverter structure, the three-phase AC motor can adapted to operate at single phase power, three-phase power or DC supply. For example, in light industries that only has single-phase power available can still use the power-efficient three-phase motor by rectifying the single-phase power line into three-phase power.

Sometimes the AC motor drive is referred as AC inverters, since the inverter is the primary component of the motor drive. A voltage-source inverter is consists of a power stage and a control unit.

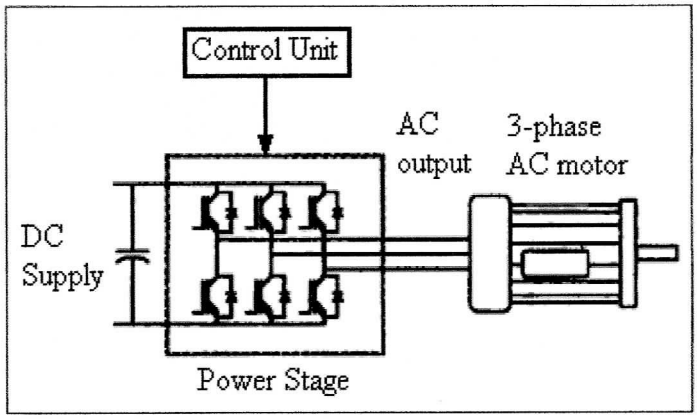

Figure 1.3 Voltage-source inverter

A power stage consists of the inverter (three half H-bridge drivers), which is the switching component. The switching is used to switch the DC source and allow current to be driven into and out of each phase of the motor. These half H-bridge drivers are controlled by control unit, to create the proper AC waveform. The power stage is the critical to overall motor drive performance. Power electronics devices and gate drive design plays important roles in switching performance and the thermal management.

The control unit determines the operations and performance of the AC motor drive. The control unit generates the PWM (Pulsed Width Modulator) gate signal. This PWM will control the switching sequence, thus affecting the power stage output.

1.3. OVERVIEW OF MAJOR COMPONENT INVOLVED

1.3.1. INTEGRATED POWER MODULE IRAMS

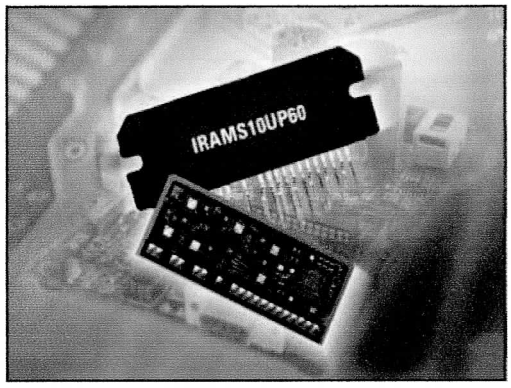

Figure 1.4 IPM IRAMS10UP60A

The power integrated module (IPM) IRAMS10UP60A PlugNDrive™ is developed and optimized for 3 phase motor drive circuits in home appliances and light industrial applications, such as washing machine, refrigerator, air-conditioner and others. The module

features a three-phase inverter power stage with gate drivers and auxiliary circuitry in a compact, high performance and isolated package.

The new devices combine International Rectifier (IR)'s low loss non-punch-through (NPT) short circuit-rated IGBT with a three phase high voltage, high speed driver IC and over 20 individual parts into a single unit.

The new modules, plus a few external components and one microcontroller enable a complete variable speed motor drive in appliances, since it is easy to implement, saves design time, decreases system cost and ultimately enables an energy-saving appliance.

The IPM has several advantages over the normal IGBT design, where voltage spike reduction and the ability to operate at higher switching frequency with lower switching losses, IPM also offer simple power connection, just V^+, the emitter connections Le1, Le2 and Le3 and the motor connection U (red),V (yellow) and W (blue).

The IPM driver requires only 6 logic level inputs and 3 bootstrap capacitors selected for the switching frequency.

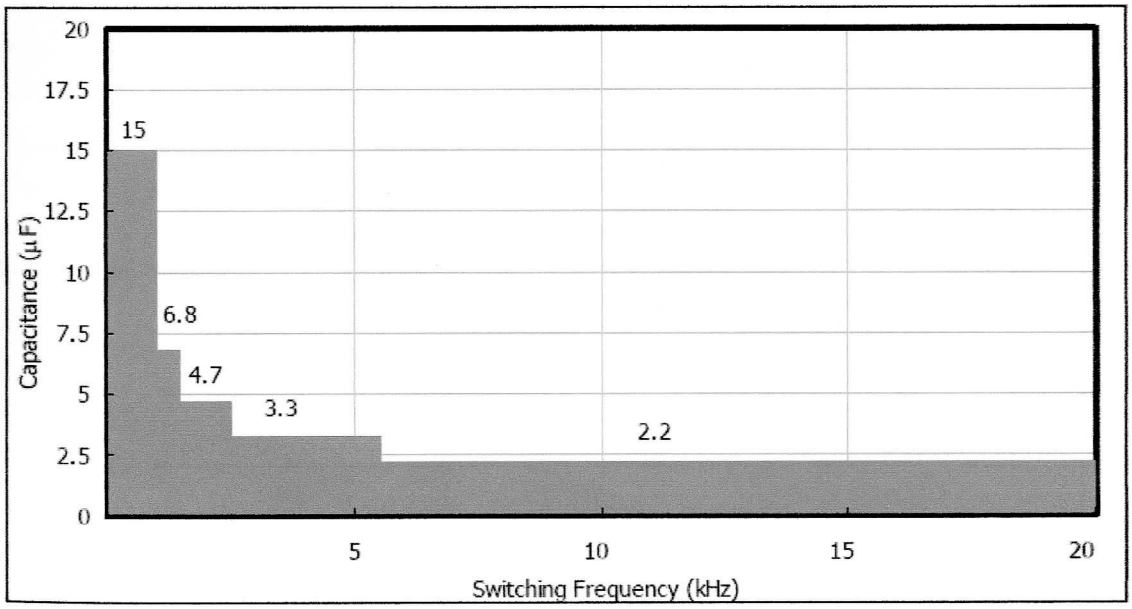

Figure 1.5 Bootstrap capacitor values vs. switching frequency

The propagation delays for all low side and high side IGBTs are matched to prevent DC core flux from being applied to the motor. Also, the built in dead time control prevents conduction overlap between high side and low side IGBTs.

Integrated power module IRAMS capable of reducing the energy consumption up to 30%. With rated at 10Ampere, IRAMS deliver a complete power stage solution for energy-efficient appliance and light industrial equipment driven by variable speed motors ranging from 400W to 2500W.

Built-in over-temperature and over-current protection and integrated under-voltage lockout functions deliver fail-safe operation to the drive system.

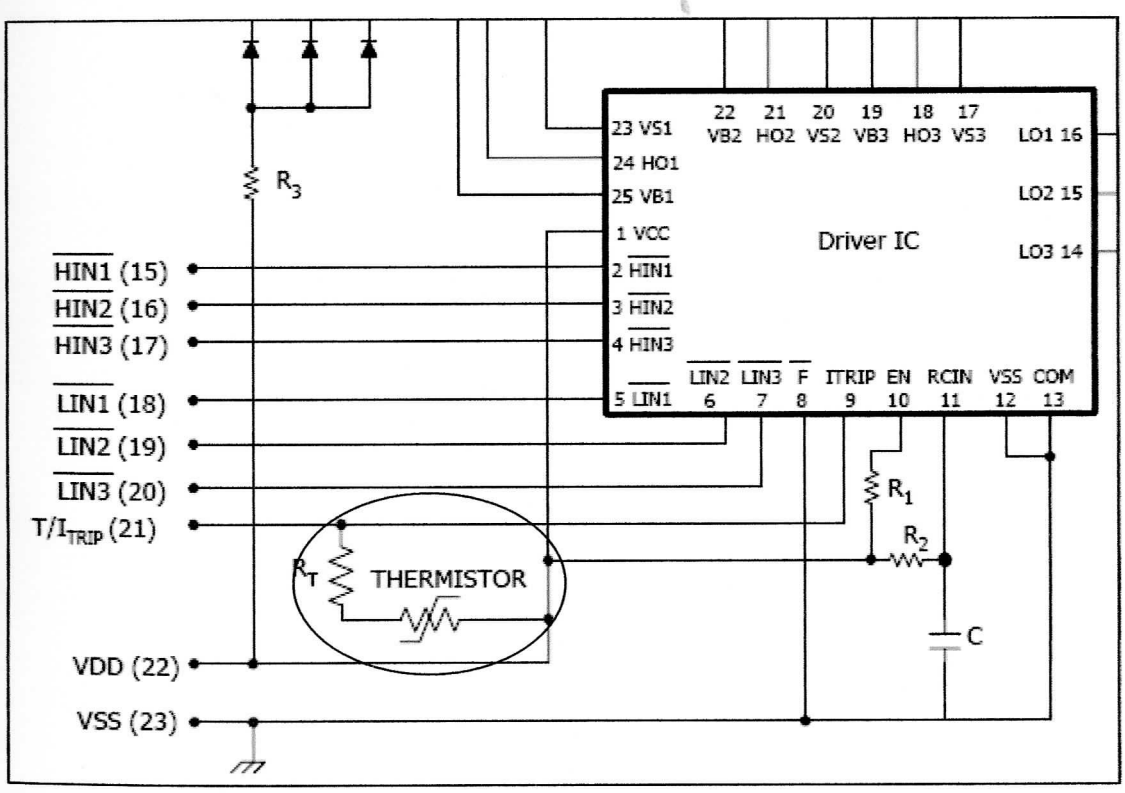

Figure 1.6 Over-temperature protection

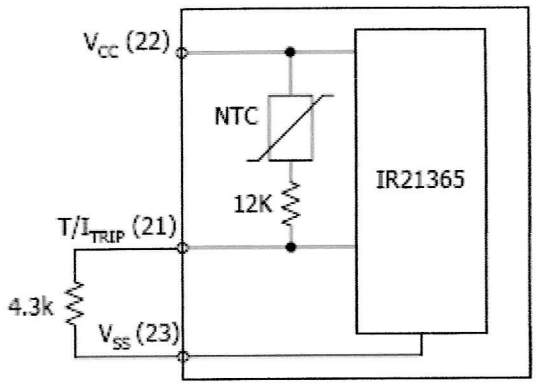

Figure 1.7 Thermistor Build in- IRAMS

Bootstrap diodes (Dbs) in the high-side driver section combine with the required single polarity power supply to simplify circuits. When high side switch or diode conducts, the bootstrap diode supports the entire bus voltage.

Average current handled by the bootstrap diode is given by the product of the charge supplied to bootstrap capacitor (Cbs) during every switching cycle and the switching frequency (fsw). In order to minimize the power loss in the diode and to reduce the size of the bootstrap capacitor, reverse recovery charge in Dbs should be as low as possible. For the same reason, reverse leakage current should also be low at the highest operating temperature. Finally, the knee voltage of the diode should be low to minimize the voltage drop across it during charging.

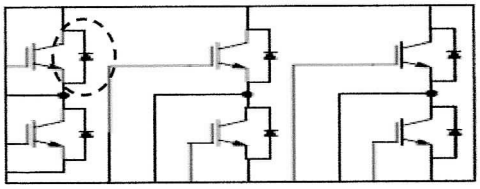

Figure 1.8 Bootstrap diodes

Parameter	Description	Max. Value	Units
V_{CES}	Maximum IGBT Blocking Voltage	600	V
V^+	Positive Bus Input Voltage	450	
I_O @ Tc = 25°C	RMS Phase Current	10	A
I_O @ Tc = 100°C	RMS Phase Current	5	
I_{PK}	Maximum Peak Phase Current (Tp<100ms)	15	
F_P	Maximum PWM Carrier Frequency	20	KHz
P_D	Maximum Power Dissipation Per Phase	20	W
V_{ISO}	Isolation Voltage (1min)	2000	V_{RMS}
$T_{J(IGBT \& DIODE)}$	Operating Junction Temperature Range	-40 to +150	°C
$T_{J(DRIVER\ IC)}$	Operating Junction Temperature Range	-40 to +150	
T	Mounting Torque Range (M3 Screw)	0.8 to 1.0	Nm

Table 1.1 Absolute maximum rating

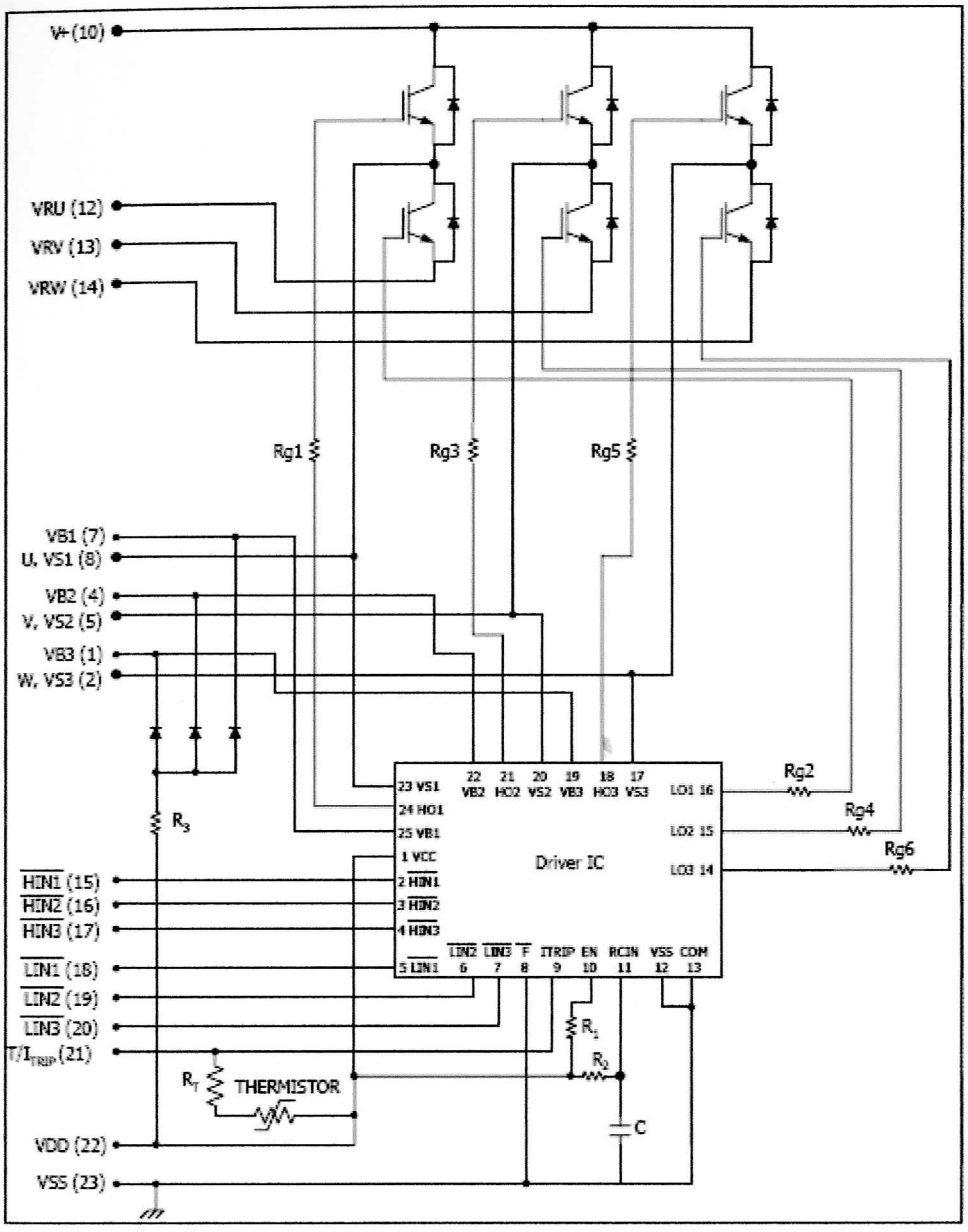

Figure 1.9 Internal Electrical Schematic – IRAMS