I hereby declare that I have read through this report entitle "Automatic Suction Control of Electrical Vacuum Cleaner" and found that it has comply the partial fulfillment for awarding the Bachelor of Electrical Engineering (Control, Instrumentation and Automation) .

Signature : .....

Supervisor's Name : .....

Date : .....

AUTOMATIC SUCTION CONTROL OF ELECTRICAL VACUUM CLEANER

CHEW YIYING (B011310017)

BEKU 4894 Final Year Project 2 Report

Faculty of Electrical Engineering

Supervisor: Mr. Muhamad Khairi Bin Aripin

SEM 2 2015/2016

I declare that this report entitle "Automatic Suction Control of Electrical Vacuum Cleaner " is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature : .....

Name : .....

Date : .....

I dedicate this report affectionately to my beloved supervisor of subject Final Year Project 2 (BEKU 4894), Mr. Muhamad Khairi Bin Aripin. He was the one who keep on trying to help me until my project was done successfully. Even though having a lot of works, he still tried his best to help me without any excuses.

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Abstract

Vacuum cleaner is commonly used by individual in household and also in most of the indoor buildings, such as office, supermarket or shops. Individual nowadays prefer automatic systems rather than manual equipment, where broom or cloths are gradually replaced by vacuum cleaner in cleaning process. The invention of vacuum cleaner is to ease users to clean up the environment without spending too much energy and time, since it offer a better efficiency. However, the vacuum cleaner nowadays consuming very high power, which causing electric bill of user raise high, yet lead to not environmental friendly issue. This automatic suction vacuum cleaner is designed to reduce the usage of electricity, where lower power is sufficient on shiny surface compared to non-shiny surface. The automatic power changing system will trigger lower power of AC motor so that it save electricity when using on shiny surface which high power is not necessary. A photoelectric sensor is designed to detect the type of surface which the vacuum cleaner is applied to. Once the sensor determined the type of surface, it will automatically trigger the motor either in higher power on non-shiny surface or lower power on shiny surface. Besides, an additional manual switch is added so that user can choose to use high power or low power or automatic mode when using the vacuum cleaner. This function will allow user to clean some hard dirt with high power on shiny surface if low power is not sufficient. Some carpet are made of special fabric where high power will spoil its material, and hence low power can be selected by user manually when cleaning on such kind of non-shiny surface. An automatic sensed and trigger function is nowadays needed in human life since the used of automatic technologies nowadays is getting more common. The developing of this automatic suction of electric vacuum cleaner will definitely help in conserve the energy and consequently help to reduce amount to pay on electric bills every month.

Abstrak

Pembersih hampagas biasanya diguna oleh pengguna di dalam rumah atau kebanyaakan dalam tempat bertutup seperti pejabat, pasar raya atau kedai-kedai. Pengguna masa kini lebih gemar alatan yang automatik daripada alatan manual, di mana penyapu dan kain telah diganti oleh pembersih hampagas secara beransur-ansur. Ciptaan pembersih hampagas adalah untuk menberi kesenangan kepada pengguna supaya dapat menjimat masa dan tenaga sedangkan ia memberi kesanan yang lebih cekap dan efisyen. Walau bagaimanapun, pembersih hampagas sedia ada memerlukan kuasa tenaga yang amat tinggi, menyebabkan bil elektrik penguna naik mendadak secara tidak langsung dan juga tidak mesra alam. Pembersih hampagas automatik ini direka untuk mengurangkan penggunaan elektrik, sedangkan kuasa yang rendah adalah mencukupi untuk pembersihan di atas permukaan kilat berbanding dengan permukaan tidak kilat. System penukaran dalam pembersih hampagas automatik ini akan menjalankan motor dengan kuasa rendah supaya dapat menjimat elektrik sedangakn kuasa tinggi tidak diperlukan ketika penggunaan atas permukaan kilat. Pengesan fotoelektrik telah diletakkan dalam sistem ini supaya dapat mengesan jenis permukaan. Apabila pengesan menentukan jenis permukaan lantai, maka sistem akan automatik menjalankan motor sama ada dengan kuasa tinggi di permukaan tidak kilat atau kuasa rendah di permukaan kilat. Selain itu, suis tambahan telah ditambah dalam sistem ini supaya pengguna boleh memilih kuasa pembersih hampagas secara manual sama ada kuasa tinggi atau kuasa rendah. Fungsi ini tersedia kepada pengguna sekiranya pengguna memerlukan kuasa tinggi ketika penggunaan tersebut berada di permukaan kilat. Sesetengah permaidani yang diperbuat daripada kain yang halus memerlukan kuasa yang lebih rendah supaya tidak merosakkan fabirk tersebut, oleh itu, fungsi ini memberi pilihan kepada pengguna untuk menggunakan kuasa rendah di permukaan tidak kilat. Fungsi automatik makin diperlukan oleh pengguna masa kini sedangkan teknologi kini semakin maju. Rekaan pembersih hampagas automatik ini dapat membantu dalam menjimatkan tenaga dan seterusnya mengurangkan bayaran yang dikenakan dalam bil elektrik pengguna.

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LIST OF ACRONYM

A	-	Ampere
AC	-	Alternating Current
DC	-	Direct Current
L.E.D	-	Light-emitting Diode
PCB	-	Printed Circuit Board
PIC	-	Peripheral Interface Controller
V	-	Volt

LIST OF SYMBOLS

dpu_c	-	Dust Pick Up Ratio on Carpet
dpu_{hf}	-	Dust Pick Up Ratio on Hard Floor

CHAPTER 1

INTRODUCTION

1.1 Project Background

This project is designed so that the vacuum cleaner detects the type of surface of the floor which the vacuum cleaner is applied to and changed the power of the vacuum cleaner automatically according to the type of the surface. A shiny surface such as marble tile will result in the lower output power, while non-shiny surface such as carpet will result a higher output power of the vacuum cleaner.

Vacuum cleaner are nowadays commonly used to replace the traditional broom or cloths in cleaning as it is more efficient compared to those traditional method. However, the consumption of power for a vacuum cleaner is very high, from 500W up to 2000W. Consequently, this lead to a higher electric bill every month.

Besides, the high power usage of vacuum cleaner is not environment friendly since energy conservation is nowadays an important issue and waste of energy is hardly prevented by everyone. However, the wrong concept have been implanted in most of the user's mind-set, which they prefer a high power consumption vacuum cleaner compare to a low power vacuum cleaner. A high power vacuum cleaner is more powerful to suck up all the dust and impurities.

The market of vacuum cleaner is currently selling high power vacuum cleaner and they claim that it is powerful enough to clean all the dust especially on non-shiny surface. In fact, a carpet or non-shiny surface need more power to suck the dusts compared to shiny surfaces. Hence, a power adjustable vacuum cleaner is needed so that the vacuum cleaner can function at its maximum power rating on a non-shiny surface and lower down its power when cleaning on a shiny surface.

A manual power adjustable vacuum cleaner however is not sufficient enough as some of the user still prefer the most convenient way, which use the maximum power on any surface without switching between two modes. Hence, the automatic suction control of electrical vacuum cleaner is designed, which can detect the type of surface and adjust the output power of the vacuum cleaner accordingly.

1.2 Problem Statement

In 24-century nowadays, most of us prefer automatic system compared to manual system. Vacuum cleaner is able to function well at a lower output power on shiny surface compared to non-shiny surface. However, vacuum cleaner nowadays have only one power button to either turn on or off without considering the power consumption and hence causing the electrical bill raise higher. Besides, the one power mode vacuum cleaner is also not environment friendly as power consumption of vacuum cleaner is high and lead to waste of energy.

1.3 Objectives

There are a few objectives of this project as stated below:

1. To design control circuit for a vacuum cleaner so that it become more power saving. The circuit is used to control the speed of the motor to suck the impurities on the floor in two different power mode depending on the type of floor.
2. To modify the existing vacuum cleaner in current market so that the vacuum cleaner has the following features and function:
    i. Have automatic mode changing function so that it can change mode without the need of manual changing.
    ii. Have the function of detecting the type of surface of the floor so that it can trigger the mode changing function automatically.
    iii. Have the function of manual mode changing besides automatic changing function, so that user can change it manually if the sensor is not functioning as desired.
3. To apply the electrical knowledge learnt in lecture rooms in the designing and modifying to ensure the application of theory is successful.

1.4 Motivation

Power saving is a main issue to consider when designing an electrical appliances. Power saving appliances not only can help to reduce the electric bill for the users, but also can help to conserve energy which is environment friendly. On the other hand, automatic system can also help to save the time of user, which can reach the maximum efficiency of the work, within the shortest time.

1.5 Project Scope

This project need to design the control circuit and modified the vacuum cleaner in current market. It needed the application of knowledge in the field of electrical, electronic and mechanical. The use of photoelectric sensor, capacitor, relay circuit and other electronic devices are needed. AC Ametek motor (Model: 119573-01) is selected as the motor of the vacuum cleaner. The sensor of the project used its photoelectric sensor which used to differentiate the shiny and non-shiny surface.

1.6 Report Organisation

In this report, the first chapter will be the introduction for the entire project. Chapter 2 will discuss about the literature review which related to the vacuum cleaner and all components related to vacuum cleaner. Chapter 3 will shows the methodology of the project where the flow of the project will be presented and the circuit designed. Chapter 4 shows the result of this project, where the data given by the motor and performance analysis of the vacuum cleaner is presented and discussed. Chapter 5 will conclude the whole project and recommend some idea for future improvement.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Most of human spent more than 70% of their daily time indoor and hence they need a very clean indoor environment to ensure the quality of their time spent within these period. According to [1], indoor air contains more pollutants compared to outdoor air due to the poisonous chemicals, air tightness, smell of food and ticks which generated by the equipment or human in that space. Vacuum cleaner is a home appliance which used to remove these harmful matters from the surrounding. There are many types of vacuum cleaner which include hybrid vacuum cleaner, wet vacuum cleaner, dry vacuum cleaner and others. A normal sized household vacuum cleaner can consume power within 500 or up to 3000 Watts. An efficient vacuum cleaner which is powerful enough to pick up all the dust might consume power up to 1300 Watts. The higher the power, the more powerful the motor suction, the more efficient the vacuum cleaner. According to Dutch Trade Association annual report [2], the sales of vacuum cleaner with rating more than 1800W is increasing from years to years. Table 2.1 below shows the percentage of sales for vacuum cleaner with rating more than 1800W from year 2003 to year 2007.

Table 2.1: Sales for vacuum cleaner with rating more than 1.8kW from 2003 to 2007 [2]

Year	2003	2004	2005	2006	2007
>1800W	8%	14%	18%	28%	39%

According to AEA Energy and Environment [3], consumer nowadays associate the power rating with cleaning efficiency. Analysis of the magazine “Which?” reveal the input power ratings of vacuum cleaners increased year by year. The report shows the product tested are in the range from 150 to 950W in the year of 1960. However, the information obtained from the retail catalogues confirm the trend which showing the vacuum cleaners

input power raised from a lower to higher range. Several model are surveyed by AEA Energy & Environment [3] which shows in Table 2.2, which the trend of the power consumption is confirmed to raise from a lower to higher range.

Table 2.2: Input Power Range for Vacuum Cleaner for Year 2003 and 2008 [2]

Type	Input Power Range 2003	Input Power Range 2008
Bagged Upright Cleaners	1300~1800W	1150~2000W
Bagless Upright Cleaners	1450~1700W	1000~2000W
Bagged Cylinders	1100~1800W	1200~2500W
Bagless Cylinders	1400~2000W	1400~2400W

However, according to the Europe Commission Regulation in Eco design requirements for vacuum cleaners [4], the rated input power of vacuum cleaners shall be less than 1600W. Starting from September 2017, the maximum rated input power will be lower down to 900W. According to Topten.eu [5], a 1000W vacuum cleaner is able to pick up dust up to 82% when a dust pickup test on carpet is carried out, whereas other higher input power vacuum cleaner does not improve the performance. This shows that 1000W of rated input power is sufficient enough to clean the dust on the carpet. The concept of having higher input power rating is more sufficient is not accurate.

By referring to the Europe Commission Delegated Regulation on energy labelling of vacuum cleaners [6], there are 7 cleaning performance classes, which the vacuum cleaners are graded according to the dust pick up performance on carpet and hard floor. The grading of each class is given a range of dust pick up performance on carpet (dpu_c) and dust pick up performance on hard floor (dpu_{hf}). The dpu_c and dpu_{hf} is the ratio of the mass of the artificial dust removed when undergoing the specific test, stated in the Europe Commission Delegated Regulation. The dpu_c and dpu_{hf} is having the different range for each class, as shown in Table 2.3.

Table 2.3: Cleaning Performance Classes for Vacuum Cleaner [6]

Cleaning Performance Class	Dust Pick Up on Carpet (dpu_c)	Dust Pick Up on hard floor (dpu_{hf})
A	$dpu_c \geq 0.91$	$dpu_{hf} \geq 1.11$
B	$0.87 \leq dpu_c < 0.91$	$1.08 \leq dpu_{hf} < 1.11$
C	$0.83 \leq dpu_c < 0.87$	$1.05 \leq dpu_{hf} < 1.08$
D	$0.79 \leq dpu_c < 0.83$	$1.02 \leq dpu_{hf} < 1.05$
E	$0.75 \leq dpu_c < 0.79$	$0.99 \leq dpu_{hf} < 1.02$
F	$0.71 \leq dpu_c < 0.75$	$0.96 \leq dpu_{hf} < 0.99$
G	$dpu_c < 0.71$	$dpu_{hf} < 0.96$

From Table 2.3, it shows that the dpu_{hf} needed to be graded for each class is much higher than the dpu_c in the same class. From here, it can estimate the dust pick up performance on carpet is usually lower than dust pick up performance on hard floor, by using same input power rating vacuum cleaner. A higher power vacuum cleaner is needed for a better performance on a non-shiny surface compared to hard floor. Hence for a common used dry vacuum cleaner which can perform well on both non-shiny surface and shiny surface needed the adjustable power output so that it can be more power saving when applying on shiny surface, yet efficient when applying on non-shiny surface. The power adjustable design will save more power and conserve the energy.

However, the power adjustable design for vacuum cleaner is not totally sufficient if it need it to manually done by user. Some user might not confident with the low power consumption when using on shiny surface and tend to use high power all the while when they use the vacuum cleaner. This can be corrected by designing the automatic suction control system and attached it in the circuit of vacuum cleaner, which gives automatic power adjustment when the sensor on the vacuum cleaner sensed the type of surface. Figure 2.1 shows the general idea of control system for an automatic suction control system that can be implemented in a vacuum cleaner.

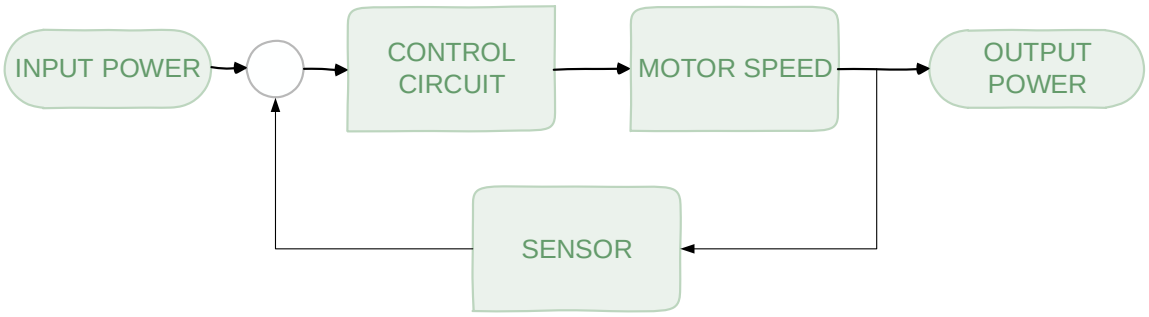

Figure 2.1: General Closed-Loop Block Diagram for Vacuum Cleaner

Figure 2.1 shows the closed loop block diagram of the system, where the mechanism will control the speed of motor, relying the feedback of the photoelectric sensor. The output power is then varied and hence reaching the objective of power saving.

2.2 AC Motor

Many types of electrical motors are used in designing household electric devices, where it includes DC motor and AC motor. DC motor used direct current which normally applied in smaller applications. AC motor is used in the electrical vacuum cleaner. There are a few types of AC motor, where these motor are categorised into synchronous motor and asynchronous motor. Asynchronous motor are commonly called induction motor. Again, asynchronous motor is divided into a few types, which include single phase, poly phase and universal motor.

By decreasing the motor speed, energy savings can be achieved. There are a few technique to control the speed of AC motor. To adjust the power of the vacuum cleaner, first of all the speed of AC motor in the vacuum cleaner need to be controlled. According to demonstration in [7], the graph of energy usage versus motor speed is plotted and it clearly shown that the faster the motor turn, the more energy consumed. Hence, by decreasing the speed of the AC motor, it can easily turned down the power consumption.

To control the speed of a AC motor, there can be a lots of ways such as changing the frequency of the AC signal by adding variable frequency drives (VFD) or adjustable speed drives (ASD), change the slip and the number of poles of the AC motor, using converter such as thyristor or IGBT chopper with diode rectifier [8] or the traditional way which

increase the slip of the motor by adding variable series resistance across the main winding of the AC motor.

2.2.1 Single Phase Motor

Single phase induction motor is a squirrel-cage motor with a single phase stator winding which shows in Figure 2.2 below.

Figure 2.2: Single Phase Motor

The single phase supply is given to the stator winding. Unlike poly-phase motor, the single phase induction motor does not have inherent starting torque. Hence, a special starting device is needed to make the single phase motor self-starting. A few starting method can be applied to the single phase motor to give torque for the motor to start-up. The following types of motor are commonly used, with different start up method [9].

i. Split-phase induction motor

Figure 2.3 shows the simple circuit for common split-phase induction motor. There are two winding which is the main winding and the auxiliary winding. The main winding is having lower resistance and higher reactance, whereas the auxiliary winding is having high resistance and low reactance. The phase angle of this type of motor is 90˚.