EXPANSION OF INPUT / OUTPUT PLC OMRON CJ1GCPU42H USING PIC

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This report is submitted in partial fulfillment of the requirements for the award of Bachelor of Electronics Engineering (Computer Engineering) With Honours

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University Technical Malaysia Malacca

April 2009

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : **EXPANSION OF INPUT / OUTPUT PLC OMRON CJ1GCPU42H USING PIC**
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This book is dedicated to my parents, family members and friends.

Last but not least, to my supervisor and all the UTeM lecturers.

Acknowledgement

This project would not have been possible without the support of many people. Many thanks to my supervisor, Mr. Farid Arafat Bin Azidin, who read my numerous revisions and helped make some sense of the confusion. He always provides the excellent guidance, concern and informative discussions regarding to my project. I would like to express my most sincere gratitude and appreciation to him and everyone who give help to me during the process to accomplish this project. And finally, thanks to my beloved family members for their unconditional love, support and patience and at last to numerous friends.

ABSTRACT

Programmable Logic Control (PLC) is the control hubs for a wide variety of automated systems and processes. It contains multiple inputs and outputs that use transistors and other circuitry to simulate switches and relays to control equipment. This is microcontroller based project which is using a microcontroller to expand the inputs / outputs of the PLC OMRON CJ1GCPU42H. This project was developed with the main objective to expand the inputs / outputs for PLC inexpensively using PIC while maintaining standard PLC input properties and functionality. The project is useful for those UTeM students who will be use the PLC as a tool for them to do their research in the future.

ABSTRAK

Programmable Logik Kawalan ialah suatu pusat kawalan yang mempunyai pelbagai fungsi dalam automatik system dan proses. Ia mengandungi banyak input dan output yang menggunakan transistor dan lain litar yang simulasi suis dan relay untuk kawalkan sesuatu alat. Projek ini mengunakan kawalan mikro sebagai asas projek iaitu dengan menggunakan kawalan mikro untuk membanyakan input atau ouput bagi PLC OMRON CJ1GCPU42H. Projek ini dihasilkan dengan tujuan untuk membanyakan input atau output bagi PLC dengan mengunakan PIC secara kos rendah tanpa mengubahkan asal unsur dan fungsi bagi input PLC yang sedia ada. Projek ini dapat membantu pelajar UTeM di mana mereka yang akan mengguna PLC sebagai alat untuk membuat kajian mereka pada masa hadapan.

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LIST OF ABBREVIATIONS

ALU	–	Arithmetic Logic Unit
ASCII	–	American Standard Code for Information Interchange
CCP	–	Capture, PWM
CCS C Compiler	–	Customer Computer Service C Compiler
CISC	–	Complex Instruction Set Computer
CPU	–	Center Processing Unit
EEPROM	–	Electrical Erasable Programming Read Only Memory
IDE	–	Integrated Developement Environment
I/O	–	Input / Output
MSB	–	Most Significant Bit
NVM	–	non-volatile storage
PCB	–	Printed Circuit Board
PIC	–	Programmable Interface Controller or Programmable Intelligent Computer
PID	–	Proportional – Integral – Derivation
PLC	–	Programmable Logic Controller
PWM	–	Pulse Width Modulation
RAM	–	Random Access Memory
RISC	–	Reduce Instruction Set Computer
RTOS	–	Real Time Operating System
LCD	–	Liquid Crystal Display
LED	–	Light Emitter Diode
LSB	–	Least Significant Bit

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CHAPTER I

INTRODUCTION

Programmable Interface Controller or Programmable Intelligent Computer (PIC) is made by Microchip Technology. It contains a processor core, memory, and programmable input / output peripherals. Besides that, it is cheaper and consumes less power compare to the microprocessor. PIC is very powerful and useful because it can be use for many types of applications such as automobile engine control systems, remote controls, office machines, appliances, expansion of ports and etc.

Programmable Logic Controller (PLC) is a digital computer used for automation of industrial processes, such as control of machinery on factory assembly lines. It is unlike general-purpose computers because it is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. It is also an example of a real time system since its output results must be produced in response to its input conditions within a bounded time, otherwise unintended operation will result. The functionality of the PLC has evolved over the years to include sequential relay control, motion control, process control, distributed control systems and networking. The data handling, storage, processing power and communication capabilities of some modern PLCs are approximately equivalent to desktop computers. PLC-like programming combined with remote I/O hardware, allow a general-purpose desktop computer to overlap some PLCs in certain applications

1.1 Background Of Project

The PLC OMRON CJ1GCPU42H has 16 inputs and 16 outputs. This project will expand the output from PLC while maintaining its standard input properties and functionality. In this project, 3 inputs / outputs from the PLC will be use to expand the PLC outputs and the total outputs for PLC will become 20 outputs after the modification is done. The combination of PIC 16F877A and external relay are needed in order to expand the input / output from PLC. Besides that, some of the programming languages such as CX – programming and C language will be use in the project, where CX – programming will be use in PLC and C language will be use in PIC.

In this project, development process will be focus on the interface between PLC and PIC because they will affect the entire cost of the project by choosing the components.

1.2 Project Objectives

The following objectives are needed as a guide to achieve the goal of this project:

i) To expands the PLC inputs / outputs using microcontroller while maintaining standard PLC's input properties and functionality.
ii) To allow interface between 2 control elements (PLC and PIC).
iii) To use as low as possible in the cost of components for the design.
iv) To use as small as possible in the space for the PCB board to expand the PLC's outputs / inputs.
v) To implement what had learnt in microcontroller and industrial control to the project.

1.3 Problem Statement

The major problem faced by designer when the situation require a microcontroller to control the system is spend too much time on program development process. Based on common microcontroller in the market such as PIC (Programmable Interrupt Controller), a complete and successful compiled source code is necessary to operate the PIC. Normally, most of the time is spend on writing the source code.

The important of this project is expanded the port of the PLC in the University Technical Malaysia Malacca's laboratory so that the PLC can become 4 times more ports than the original ports. This is because the PLCs in the laboratory are not enough for the students to do their research work.

Beside that, another problem often faced by programmer is lots of error occurred during compiling the source code. Although the compiler program able to debug and provide a reference for user to make correction, but sometime is too complicated and wasting time to make correction for all the errors.

Based on research and study result, the interface between PIC and PLC is the most headache problem for the designer. This is because there are 2 problems will be encounter in this path. The first one is step down the voltage from PLC because the voltage can be supported in PIC is about 5V only, whereas the voltage on PLC is about 24V. The other one is step up the voltage from PIC in order to complete the project. This will affect the cost of the entire project.

1.4 Scope Of Work

This final project basically is expanded the outputs for PLC OMRON CJ1GCPU42H. Therefore there will be 2 main components, PLC OMRON CJ1GCPU42H and PIC 16F877A, to be use in this project.

Design and simulation will be performed using CX program for PLC. Whereas for the PIC, there will be using 3 software, PIC C compiler, PROTEUS 6.9 VSM and WinPIC. The successful simulated program will be downloading to the PIC using WinPIC. Testing on PCB board will also be carried out when all the designs and simulations have done.

The design will then be transferred to PCB as prototyping using Proteus ARES. Then proceed with etching and soldering process. Testing and troubleshooting on the prototype model will be done to ensure the functionality of the prototype.

1.5 Short Brief On Methodology

To develop the project during PSM-I, CX – program had used for design the ladder diagram for the PLC and CCS C compiler had used for design the program for the PIC16F877A.

After that, the error free program will be converted to hex code through CCS C compiler. This hex code will be tested in PROTEUS 6.7 to determine some error that can not be trace by PIC C compiler.

When everything is done without any problem then the program will be tested using 3 push buttons which will be connected to PIC16F877A to verify the program. Then it will proceed to circuit layout design by using PROTEUS ARES. This layout will be etched to the positive acting PCB and then solder the components to the PCB. If everything is ok then the project is done.

1.6 Thesis Outline

This thesis consists of five chapters which are Chapter 1, Chapter 2, Chapter 3, Chapter 4, and Chapter 5. In Chapter 1, it will discuss the introduction of the project which includes the objective of the project, problem statement, scopes of work, methodology, and the important of the project.

In Chapter 2, it will describe the literature review had been done for the project. Every facts and information which is found through journals or other references where later on it will be implement in the project.

The methodology of the project will be discussed in Chapter 3. The project methodology will be covered the two main parts which is software development part and hardware creation part. In software creation part, software like PIC C compiler and CX – programmer will be to develop the software part and PROTEUS ISIS will be used for testing the hex code generated by PIC C compiler, whereas in hardware creation part will discussed the process of etching, drilling, and soldering.

In Chapter 4, it will display the results for the software development part and hardware creation part discussed in Chapter 3. All of these results will be show in the form of figures only. Besides that, there will be some discussion about the simulation, C programming and hardware part that had done in the project.

Lastly, the Chapter 5 will summarize the project and it will also discuss the conclusion of the project and suggestions or recommendations in the future work.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter reviews some references from previous projects, journals, articles, books and datasheets. All these information were collected from the different sources such as library, internet, product manual and etc. The useful data will be discussed on this chapter.

2.2 Research And Study

Nowadays, there are many types of compilers to program the microcontroller in PIC field. They are used to translate source code from a high-level programming language such as C++ or C to a lower level programming languages such as machine code or assembler language. For example, just take a common microcontroller which is PIC16F877A. It has many program compilers supported such as PIC C Compiler, PIC C Compiler, PIC Simulator IDE, PIC Basic or SourceBoost IDE and etc. All of these compilers require the program instructions or known as source codes to generate the Hex code. These source codes all are in C language which is also know as high level programming language. With these compilers and microcontrollers, many modifications for the hardware can be done easily without changing the hardware part. In this report, there will be some comparison for PICs.

2.3 Microcontroller

A microcontroller is all the components of the microcomputer system such as Central Processing Unit (CPU), Arithmetic Logic Unit (ALU), input / output (I / O) and peripherals devices combined together onto one integrated chip. It emphasizes high integration, in contrast to a microprocessor which only contains a CPU. In addition to the usual arithmetic and logic elements of a general purpose microprocessor, the microcontroller integrates additional elements such as read-write memory for data storage, read-only memory for program storage, Flash memory for permanent data storage, peripherals, and input/output interfaces. At clock speeds of as little as 32KHz, microcontrollers often operate at very low speed compared to microprocessors, but this is adequate for typical applications. They consume relatively little power (milliwatts or even microwatts), and will generally have the ability to retain functionality while waiting for an event such as a button press or interrupt. Power consumption while sleeping (CPU clock and peripherals disabled) may be just nanowatts, making them ideal for low power and long lasting battery applications.

2.3.1 Comparison between PICs

In this project, the PIC16F877A will be choosing for development of the project. This PIC is chosen because of its total number of pins and cost. Besides that, the consideration for future developments of the project also is one of the reasons that this PIC is chosen.

The Table 2.1 is shows the comparison between PIC16F84 and PIC16F877A in terms of their cost, number of pins, availability in market and etc. Since the PLC has 16 inputs and 16 outputs, so the total number of pins and the cost for the PIC will be the first priority to consider in choosing PIC for the project. After that, other factors like the availability in market, performance, and etc will be take in to consideration.