



UNIVERSITI TEKNIKAL MALAYSIA MELAKA

**DESIGN AND PROTOTYPING OF SEMI-AUTOMATED
STORAGE AND RETRIEVAL SYSTEM (S-AS/RS) USING
MICROCONTROLLER**

This report submitted in accordance with requirement of the Universiti
Teknikal Malaysia Melaka (UTeM) for the Bachelor Degree of Manufacturing
Engineering (Robotic and Automation) with Honours

by

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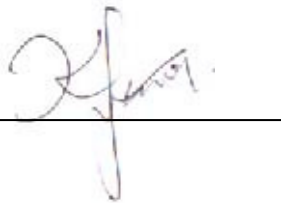
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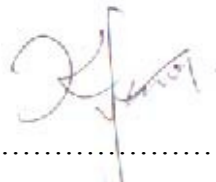
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ABSTRACT

Automated storage and retrieval system (AS/RS) is one of the material handling processes in the industrial field. Invented and still in development since 1950s. This system is still popular to become one of the researches choices to improve and increase its effectiveness and efficiency. This project report describes about the design and prototyping of semi-automated storage and retrieval system (S-AS/RS) using microcontroller. Although this system is a semi-automated system, the fully automated system of AS/RS has been chosen as a reference because of its slightly similar conditions. In this project, a semi-automated storage and retrieval system (S-AS/RS) has been designed and prototyped for mini-load storage or the light weight loads. A part of that, this project also involves of designing and fabrication of circuitry and programming, where the PIC 16F877A has been chosen as a brain of the system to control all the mechanisms. Several tests have been created to observe its ability and capability. Although all the aims have been grabbed, several improvements have been suggested to compete with the recent technology of the storage system.

ABSTRAK

Sistem simpanan dan pemerolehan semula automatik (AS/RS) adalah salah satu proses pengendalian bahan atau pun barangan dalam bidang perindustrian. Sistem ini telah dicipta dan masih dalam proses pembangunan serta penambahbaikan semenjak tahun 1950. Sistem ini juga masih popular dan menjadi salah satu pilihan dikalangan para pengkaji dan pereka untuk diperbaiki dan dipertingkatkan lagi kecekapan dan keberkesannya. Laporan projek sarjana muda ini adalah berkenaan tentang mereka dan membina prototaip sistem simpanan dan pemerolehan semula semi-automatik (S-AS/RS) menggunakan pengawalmikro. Walaupun sistem ini adalah sistem semi-automatik, namun, sistem kawalan automatik sepenuhnya iaitu sistem simpanan dan pemerolehan semula automatik (AS/RS) telah dipilih sebagai sumber rujukan, disebabkan oleh persamaan keadaan dan operasinya iaitu menyimpan dan memperoleh semula simpanan. Dalam projek ini, sistem simpanan dan pemerolehan semula semi-automatik (S-AS/RS) akan direka dan diprototaipkan untuk jenis simpanan bebanan mini ataupun simpanan bebanan ringan. Selain itu, projek ini juga merangkumi rekaan dan pembinaan litar-litar berkaitan, dan juga pengaturcaraan sistem yang mana pengawalmikro PIC16F877A telah dipilih sebagai pengawal utama sistem prototaip bagi mengawal keseluruhan mekanisma. Beberapa ujian telah direka dan dijalankan ke atas prototaip bagi menguji keupayaan dan kemampuannya. Walaupun projek ini telah mencapai sasaran seperti yang diharapkan, namun bagi menyaingi teknologi terkini dalam sistem simpanan barangan, beberapa cadangan telah dikemukakan.

DEDICATION

To my beloved family especially my parents

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LIST OF ABBREVIATIONS

AC	–	Alternating Current
AS/RS	–	Automated Storage and Retrieval System
BLDC Motor	–	Brushless Direct Current Motor
CAD	–	Computer-Aided Design
DC	–	Direct Current
DCC	–	Dual Command Cycle
FCFS	–	First-Come-First-Served
FIFO	–	First-In-First-Out
IC	–	Integrated Circuit
LCD	–	Liquid Crystal Display
LED	–	Light Emitting Diode
MCU	–	Microcontroller Unit
P&D Station	–	Pickup-and-Deposit Station
PC	–	Personal Computer
PCB Board	–	Printed Circuit Board
PIC	–	Peripheral Interface Controller
PLC	–	Programmable Logic Controller
PSM I /PSM II	–	Projek Sarjana Muda I / II
PSU	–	Power Supply Unit
PWM	–	Pulse Width Modulation
S/R Machine	–	Storage and Retrieval Machine
S-AS/RS	–	Semi-Automated Storage and Retrieval System
SCADA	–	Supervisory Control and Data Acquisition
SCC	–	Single Command Cycle
SKU	–	Stock-Keeping-Unit
UTeM	–	Universiti Teknikal Malaysia Melaka
WIP	–	Work-In-Progress

CHAPTER 1

INTRODUCTION

1.1 Background

Material handling is one of the crucial activities that involves in the manufacturing process. Material handling is defined as moving the right material to the right place, at the right time, at the right amount, and in the right position or condition to minimize production costs. Improvements in material handling have affected working people more than any other area of work design and ergonomics. Today, we can say that the physical drudgery has been reduced and continuously research tries to eliminate from work by material handling equipment (Meyers & Stephens, 2000). The material handling equipment can be classified into four categories; material transport equipment, storage systems, unitizing equipment, and identification and tracking systems. However, for this report, it tends to focus on the storage system only.

Storage system is used to store the materials for a period of time and to permit access to those materials when required. One of the storage systems that are increasingly being used is the Automated Storage and Retrieval System (AS/RS). The Automated Storage and Retrieval System (AS/RS) is one of the most important tools used in warehouse material handling and inventory control for the purpose of order picking and similar applications, as well as in modern factories for work-in-process (WIP) storage. A typical AS/RS is composed of multiple parallel aisles of racks with storage slots (cells), a storage and retrieval (S/R) machine for each aisle and an input and output (I/O) station. The S/R machine moves simultaneously in horizontal and vertical directions in order to reduce the travel time (Groover, 2008).

In designing and prototyping the Semi-Automated Storage and Retrieval System (S-AS/RS) which looks similar as the real AS/RS, many physical design and control issues have to be addressed in the right way to take advantage of all its process as in fully automated (AS/RS). Automated means, it's entirely automatic-working by itself with little or no direct human to control the system. The AS/RS is fully software aided computerized controlled, added with help of several sensors to improve its capability. According to the project title, this prototyping project intends to present issues concerning Semi-Automated Storage and Retrieval System (S-AS/RS) design and control by using microcontroller.

As the name applied, semi-automatic means partially automatic which having a mechanism for self-working but not for continuous operation. It needs a little help of man power to control or set it to follow the requirements. Although it is semi-automatic project, this prototype will have the same basic application and functional as the typical AS/RS; storage and retrieve the stock-keeping-unit (SKU) or load to and from the storage. When mentioning about the size, this prototype will exhibit in the small scale compare to the real industrial AS/RS. Although the system is in a small scale, this prototype can be used to handle a light and small load operation such as handling the small tote (container) in one operation, either to store or retrieve the item.

For this semi-automated storage and retrieval system (S-AS/RS), it is controlled by using the keypad which is used to choose the task either to store or to retrieve the load and to verify the location of the operation. Basically, this system being designed in order to bring the material to the operator; cutting the cycle time of waiting, walking, and improving the ergonomic system in the storage system by reducing or eliminating the awkward working posture and repetition of works that will contribute to the work injury. A part of that, this S-AS/RS project is conducted to handle small load (less than 500 grams) which is one of the initiative or maybe as an invention to create a further simple control system for efficiency of storage system.

1.2 Problem Statement

Storage system is one of the crucial parts for material handling in manufacturing activities. For the parts that are small, light, and less in volume, it might be easy to handle and stored. But, when the parts increase its volumes, it can become as a problem to store and to retrieve it back. By performing the conventional (manual) in material handling for storage system, it can contribute several problems that need to be reduced or eliminated, such as cannot utilize the maximum space in the warehouse or store because of limited equipment, not fully utilizing the higher space of the store, cannot use the storage system efficiently, difficult to increase the storage volume, the chance of injury to workers might happen when handling the parts or materials, and increase the ergonomic risk factor such as force, repetition, and awkward posture.

In the recent day, the most efficient method to solve the storage problem is the automated storage and retrieval system (AS/RS). This system basically focuses more to the handle large and big load. In addition, it needs higher capital and cost to implement in the storage system which is become as an issue to the small company to use this system. For the small or maybe the new company they also need 'something' to improve their storage system and want to boosts up their productivity. So the Semi-Automated Storage and Retrieval System (S-AS/RS) is the answer to be considered. In addition, it also can apply the 5S concept; Sort, Set in Order, Shine, Standardize, and Sustain which is the goal in manufacturing and industrial field that will result in improved profitability, efficiency, service and safety.

1.3 Objectives of the Project

There are several objectives that need to be considered to achieve the goals of this project which is to Design and Prototyping of Semi-Automated Storage and Retrieval System (S-AS/RS) using microcontroller which are:

- a) To develop the prototype of Mini-Load Semi-Automated Storage and Retrieval System (S-AS/RS).
- b) To control the Mini-Load Semi-Automated Storage and Retrieval System (S-AS/RS) using PIC microcontroller.

1.4 Scopes

In order to design and prototyping the Semi-Automated Storage and Retrieval System (S-AS/RS) using microcontroller, scopes are required to assist and guide the development of the project. The scopes should be identified and planned to achieve the objective of the project successfully. The scopes for this project are:

- a) Design and develop mechanical structure of Mini-Load S-AS/RS prototype model.
- b) Control the Mini-Load S-AS/RS prototype system using PIC microcontroller.
- c) The CCS C compiler is used to develop the S-AS/RS program in C language.

1.5 Benefits of the Project

The Semi-Automated Storage and Retrieval System (S-AS/RS) are being designed and prototyped using microcontroller in order to become as one of the impetus or as a starting point to create a beneficial technology of storage system operation that is affordable. Besides that, the prototype of S-AS/RS hopefully can be used as a platform to grab the long list of AS/RS benefits when it's implemented at the real

scale of the store or warehouse. Below are several benefits that can be listed for the S-AS/RS system:

- a) Affordable semi-automated storage systems (less cost).
- b) Needs a little help of man power to control or set it to follow the requirements.
- c) Reduce active participation of workers in storage system, thus increase workers safety; reduce the ergonomic risk factor such as force, repetition, and awkward posture.
- d) Reduce energy consumption.
- e) Improve storage system, thus can boosts up the productivity.
- f) Reduce time consumption to store and retrieve items in the store; cutting the cycle time of waiting and walking thus reducing the production lead time.
- g) Apply the 5S concept which is one of the industrial goals.
- h) High floor-space utilization thus used the storage system efficiently.

CHAPTER 2

LITERATURE REVIEW

2.1 Storage Systems

Storage system is one of the important activities in material handling system. It is because, there is no that raw material, work-in-process (WIP) parts, and the finished products are likely to spend sometime in a warehouse or at distribution center before being shifted to other activity. There are several types of material that are usually stored using the storage system as indicated in **Table 2.1**. (Groover, 2008, p.330). Categories number 1 to 5 relate directly to the product, number 6 to 8 relate to the process, and number 9 to 10 relate to overall support of factory operations. The material storage system is used to store materials for a period of time and to permit access to those materials when required. As the safety factor as the prime concern for the storage system, the time dimension also as one of the important thing because of to determines how quickly the material can move through the facility. The amount of the work-in-process (WIP), excessive inventories, repeated handling of the material, and order delivery lead times are affected by the aspect of the material handling system (Groover, 2008).

Table 2.1: Types of materials typically stored in a factory (Groover 2008).

No	Type	Description
1	Raw materials	Raw stock to be processed (example: bar stock, sheet metal, plastic molding compound)
2	Purchased parts	Parts from vendors to be processed or assembled (example: castings, purchased components)
3	Work-in-process	Partially completed parts between processing operations or parts awaiting assembly
4	Finished product	Completed product ready for shipment
5	Rework and scrap	Parts that do not meet specifications, either to be reworked or scrapped
6	Refuse	Chips, swarf, oils, other waste products left over after processing; these materials must be disposed of, sometimes using special precautions
7	Tooling	Cutting tools, jigs, fixtures, molds, dies, welding wire, and other tooling used in manufacturing and assembly; supplies such as helmets, gloves, and others
8	Spare parts	Parts needed for maintenance and repair of factory equipment
9	Office supplies	Paper, paper forms, writing instruments, and other items in support of plant office
10	Plant records	Record on product, equipment, and personnel

2.2 Types of Storage Systems

As mentioned before, storage systems can be described as one of the important systems that are needed in the industrial field. They play an important role in industry which will affect the productivity of the production. Basically, this system can be classified into two major categories: (1) conventional (non-automated) storage method and (2) automated storage system. Below are a little bit of explanations about both systems.