Sudan University of Science and Technology
College of Graduate Studies

Controlling Induction Motor Using Variable Speed Drive With Supervisory Control And Data Acquisition

التحكم في المحرك الحثي باستخدام قيادة متغير السرعات ونظام التحكم الاشرافي واستحواذ البيانات

A Thesis Submitted in Partial Fulfillment to the Requirements for the Degree of M.Sc. in Mechatronics Engineering

Prepared by: Fatima Assamawal Assidig Altaher

Supervised by: Dr. Alaa Aldeen Awooda

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آية الكرسي

اللّهُ لاَ إِلَـهَ إِلاَّ هُوَ الْحَيُّ الْقَيُّومُ لاَ تَأْخُذُهُ سِنَةٌ وَلاَ نَوْمٌ لَّهُ مَا فِي السَّمَاوَاتِ وَمَا فِي الأَرْضِ مَن ذَا الَّذِي يَشْفَعُ عِنْدَهُ إِلاَّ بِإِذْنِهِ يَعْلَمُ مَا بَيْنَ أَيْدِيهِمْ وَمَا خَلْفَهُمْ وَلاَ يُحِيطُونَ بِشَيْءٍ مِّنْ عِلْمِهِ إِلاَّ بِمَا شَاء وَسِعَ كُرْسِيُّهُ السَّمَاوَاتِ وَالأَرْضَ وَلاَ يَؤُودُهُ حِفْظُهُمَا وَهُوَ الْعَلِيُّ الْعَظِيمُ

سورة البقره (255) آية الكرسي

DEDICATION

I dedicate this thesis to ALLAH Almighty my creator, my strong pillar, my source of inspiration, wisdom, knowledge and understanding. He has been the source of my strength throughout this program and on His wings only have I soared, and my Master My great teacher and messenger, Mohammed (May Allah blessed grant him),

And then after I dedicate this work to my family who have always been a constant source of support and encouragement during the challenges of my whole life.

To my husband Husam and my kids Ahmed and Dan whom I am truly grateful for having in my life Thank you.

My love for you all can never be quantified. Allah bless you.

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I would like to take this opportunity to say warm thanks to all my beloved friends, who have been so supportive along the way of doing my thesis.

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Abstract

Three phase induction motors are mostly used in industry for various operations. In this thesis the Variable Frequency Derive control the speed of 3-phase induction motor based on programmable logic controller and supervisory control and data acquisition technology. An implementation of a hardware and software for speed control, direction control, parameter monitoring on supervisory control and data acquisition screen is also provided. tank filling ,bottle filling and capping system was taken as an example for control by PLC and supervisory control and data acquisition , The Variable Frequency Derive control the conveyer belt motor when it move the bottle. All the required control and motor performance monitoring data will be taken to a personal computer by supervisory control and data acquisition and smart phone application which can provide an optimization the automation process and makes the system more flexible and easy to operate

المستخلص

المحرك الحثي ثلاثي الاوجه اصبح من اكثر المحركات استخداما في الصناعة و في العديد من التطبيقات .في هذا البحث تم التحكم في سرعة المحرك الحثي ثلاثي الاوجه باستخدام مغير التردد و ذلك عن طريق المتحكم المبرمج المنطقي و نظام التحكم الاشرافي مستحوذ البيانات ا لاسكادا كما تم استخدام الكمبيوتر .تم استخدام مثال لتطبيق التحكم في المحرك الحثي في نظام تعبئة خزان يقوم بتعبئة السائل من الخزان في زجاجات استخدم نظام التحكم الاشرافي مستحوذ البيانت في تصميم النظام و التحكم فيه بمساعدة المتحكم المبرمج المنطقي حيث تم التحكم في سرعة المحرك الحثي الذي يحرك سير الحركة المستخدم لنقل و تغليف الزجاجات بواسطة مغير الترددات

LEST OF CONTENTS

Title **Page**

CHAPTER ONE

INTRODUCTION

CHAPTER TWO

LETRATURE REVIEW

CHAPTER THREE

SYSTEM DESIGN AND OPRERATION

CHAPTER FOUR

RESULTS AND DISCUSSTION

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

LEST OF FIGURES

LEST OF APPREVIATIONS

Appreviation	Description
AC	Alternative Current
CPU	Central Processor Unit
DC	Direct Current
HMI	Human Machine Interface
IM	Induction motor
PC	Personal computer
PLC	Programmable Logic Control
PWM	Pulse Width Modulation
SCADA	Supervisory Control And Data Acquisition
VFD	Variable Frequency Drive
VSD	Variable Speed Drive

CHAPTER ONE

INTRODUTION

Chapter One

Introduction

1.1 General Concepts

In this chapter will focus of brief introduction of the project to be carried out. the important overview or description including the problem statement , project objective and expected result are well emphasize in this section

SINCE technology for motion control of electric drives became available, the use of programmable logic controllers (PLCs) with power electronics in electric machines applications has been introduced in the manufacturing automation.AC induction motors (IMs) are used as actuators in many industrial processes. Although IMs are reliable.

The mechanical parts of the equipment can cause problems in the course of operation and can reduce the life and efficiency of a system so often in the industry, need arises for controlling the speed of a 3 phase induction motor. motor drives are able to efficiently control motor speed, improve machine automation and save energy. Each drive in its variable drive (VSD) series is designed to meet specific application needs. .A Variable speed Drive is used for applications where in speed control is of an essential importance due to load changes where in the speed needs to be increased or decreased accordingly. Traditional methods in existence have addressed this issue, each with their own drawbacks such as high motor starting current, lower power factor, energy losses, etc. To address these problems, VSD provides a flexible approach as compared to traditional methods of speed control especially for certain applications which do not require a constant speed at all times. To name an example, a pump delivering cooling liquid supply may require peak load operation only for a requisite period of time and may require only much less amount during the remainder of the day [1]. VSD will allow the speed of the pump to run at a lower rate in such case thereby enabling energy saving benefits

With the advent of technology and availability of motion control of electric drives, the application of Programmable Logic Controllers with power electronics in electrical machines has been introduced in the manufacturing automation systems. The use of PLC in automation processes increases reliability and flexibility and also reduces production costs. To obtain accurate industrial electric drive systems, it is necessary to use PLC interfaced with power converters, personal computers and other electric equipment , Programmable logic controllers (PLCs) support digital input/output very effectively. So a PLC can also be used to control the operation of a VSD, hence to finally control the connected 3 Phase Induction Motor also connected with Supervisory Control And Data Acquisition (SCADA) system .

SCADA is a system which exercises supervisory control of a particular device from a remote location and the human operator is able to monitor and control the device from his computer screen without being physically present near the device [2].

1.2 Problem Statement

Most industrial systems that used induction motors need to control the speed of the motor so according the kind of the industry sometimes changing the fixed speed in motor or using different speeds for cretin process in the induction motor is essential for the system , that make the controlling speed of induction motor by VSD for optimal operation is badly needed.

sometimes the location of the induction motors in certain industries is difficult or dangerous to access to be operated and controlled manually so the option of controlling induction motors remotely through PLC and SCADA system is mightily required

1.3 Proposed Solution

The VSD provides a flexible approach as compared to traditional methods of speed control especially for certain applications which do not require a constant speed at all times, also to obtain accurate industrial electric drive systems, it is necessary to use PLC interfaced with power converters, personal computers ,smart phones and other electric equipment, remote the whole operation by SCADA system .

1.4Aim And Objectives

The main aim of control the speed of induction motor is to provide different speeds to the motor when are required and save energy by using VSD to control the speed, In addition control the induction motor remotely the taken as an example filling and capping system to tank and bottle system which use VSD to control the induction motor of the conveyer belt. So to achieve this aim a system is proposed that include VSD to control the motor PLC and SCADA and smart phone to controlling , monitoring and remote the system. Simulation of the system was run ,And the practical implementation of the system is done.

1.5 Methodology

The main steps that followed to accomplish this project in an organized way:

- Collect data about VSD(variable frequency drive , induction motor .
- Designing the program the PLC to control VSD remotely
- Design the SCADA system and connected with plc .
- connect the pc with smart phone by using any desk application
- connect the hole process to gather and test it .
- Record results.

1.6 Thesis Layout

This thesis consists of five chapters including

- CHAPTER ONE: introduction Highlight problem statement and the proposed solution long with . objective
- CHAPTER TWO: literature review and previous studies also cover the system component.
- CHAPTER THREE: the design of system.
- CHAPTER FOUR: results and discussion shows different scenario for the system.
- CHAPTER FIVE: conclusion recommendation for future research.

CHAPTER TWO

LETRATURE REVIEW

Chapter Two

Literature Review

2.1 Over view

This chapter cover the previous case studies of controlling induction motor using VFD through PLC and SCADA system that have been done previously by other researchers and that is so necessary and helpful to refer to the verity of sources in order to gain more knowledge and skills to complete this project, The chapter also discuses different system part and its function.

2.2 Previous Works

Year 2015 Mihir K.Patelin Paper represents the analysis of induction motor speed control using VFD (Variable Frequency Drive) system operated by PLC-SCADA system. The main aim of the paper is to dealt with the concept of speed control of a three-phase induction motor with energy saving. To do so, a VFD (Variable Frequency Drive) is used for controlling the speed of a three-phase induction motor with variable load attached to the motor. It certainly leads to the best performance and high efficiency of the induction motor. Programmable Logic Controller (PLC) and Supervisory Control And Data Acquisition (SCADA) are two new systems to control a Variable Frequency Drive (VFD) whose output is given to a three-phase induction motor and driving a conveyor belt. The conveyor belt has three sensors are inputs which senses a passing object and carries out the necessary instructions programmed in ladder logic programming of the PLC through the computer (PC). The SCADA software installed in the PC in turn enables the human operator to control the entire operation away from the plant and just by using the virtual inputs designated on his computer screen. [3]

In year 2015 Jitendra Kumar Vermapresent paper the title is Implementation of PLC in VFD Controlled Induction Motor. forces of deregulation and competition have also influence the organizational utilities – forcing the growth of automation and information strategies competitive industries. Tests have proved that an inverter driven induction motor system, controlled by PLC makes possible higher accuracy in speed regulation when compared to a conventional V/f control system. The proposed design covers the implementation parameters directing to improve the human machine interaction. This computer controlled systems has the ability to continuously develop its control strategy conditions for flexible operations. The tasks controlled through the control panel include customized starting, direction controlling and speed controlling and Limit switch.[4]

The paper PLC Application for speed control of induction motor through VFD presented by Ms. N. M. Rao1year 2017 is about controlling the speed of a three phase induction motor using variable frequency drive(VFD) through programmable logic controller(PLC). Programmable logic controller is an industrial controlling device and is used to automate machines and factory assembly lines. Main purpose of this paper is to automate the three phase induction motor by controlling the inputs to variable frequency drive through PLC and therefore as a result the inputs to the induction motor will be changed and thus the speed of induction motor will changed accordingly. VFD employed in this experiment is based on V/f method of speed control in which flux remain constant.[5]

According to the paper Induction Motor Speed Control Using PLC AND SCADA which prepared by Gupta V year 2018 Automation can be defined as the technology by which a process or way is performed without human succor. automatic control, is the use of various control system for operating equipment such as machinery, processes in industries, boilers and electrostatic precipitator, switching on communication networks, navigation and stabilization of ships, aircraft and other applications and vehicles with trifling human intervention. Some processes have been completely automated. The motor speed is controlled via the driver as an open loop control system. To make a more accurate closed loop control of motor speed we will use a tachometer (revolution-counter, tach, rev-counter, RPM gauge) to measure the speed and feed it back to the PLC, which compares to the desired value and take a control action, then the signal is transferred to the motor – via driver – to increase / decrease the speed. We will measure the speed of the motor using an incremental rotary encoder by adjusting parameters (PLC, driver) and also, we need to reduce the overall cost of the system. Our control system will be held using the available Siemens PLC. In addition, we will monitor motor parameters via SCADA system.[6].

Prof. Dr. D.S.Bankar present in year 2018 a paper title Control of Induction Motor Using PLC and VFD about In electrical machine technology there are different types of motor available and one has to choose the proper motor type depending on his/her own requirements and applications. However, the most widely used and more efficient motor available of all is the Induction Motors. Hence, it initiates a need to control various parameters of induction motor in order to run it properly and efficiently. This paper shows the "Direct On-line Starter" and speed management of 3-phase induction motor through VFD. There are many different methods and starter available to start the motor out of which DOL (Direct Online Starter) is very simple and cheap. To control the speed of induction motor many techniques and drives are available out of which VFD (Variable Frequency Drive) is used here. The employment of VFD will increase potency, reliability, energy savings and supply speed variation. PLC is employed for beginning the DOL starter and also the main side of victimization PLC is to try and do operation remotely.[7].

2.1 Induction motor

A motor with only armature windings is called an induction motor. An induction motor is the most modest electrical machine from constructional point of view, in the majority of the cases. Induction motor works on the principle of induction where electro-magnetic field is induced into the rotor when rotating magnetic field of stator cuts the stationary rotor. Figure 2.1 show induction motor

Figure2. 1Induction motor

Induction machines are by far the most common type of motor used in industrial, commercial or residential settings. It is a three phase AC motor. Its characteristic features are:

- Simple and rugged construction
- Low cost and minimum maintenance
- High dependability and sufficiently high proficiency
- Needs no additional starting motor and necessity not be synchronized

2.1.1 Construction of a 3 phase induction motor

Just like any other motor, a 3 phase induction motor also consists of a stator and a rotor. Basically there are two types of 3 phase IM - 1. Squirrel cage induction motor and 2. Phase Wound induction motor (slip-ring induction motor). Both types have similar constructed rotor, but they differ in construction of rotor. This is explained further. The stator of a 3 phase IM (Induction Motor) is made up with number of stampings, and these stampings are slotted to receive the stator winding. The stator is wound with a 3 phase winding which is fed from a 3 phase supply as It is wound for a defined number of poles, and the number of poles is determined from the required speed. For greater speed, lesser number of poles is used and vice versa. When stator windings are supplied with 3 phase ac supply, they produce alternating flux which revolves with synchronous speed. The synchronous speed is inversely proportional to number of poles ($Ns = 120f / P$). This revolving or rotating magnetic flux induces current in rotor windings according to Faraday's law of mutual induction. An induction motor has basically two parts: Stator and Rotor. The stator is made up of various stampings with slots to carry three phase windings. It is wound for a distinct number of poles. The windings are geometrically divided 120 degrees separated. Two sorts of rotors are used in Induction motors: Squirrel cage rotor and Wound rotor. No DC field current is required to run the machine. Rotor voltage is induced in the rotor windings rather than being physically connected by wires**.** figure 2.2shown stator

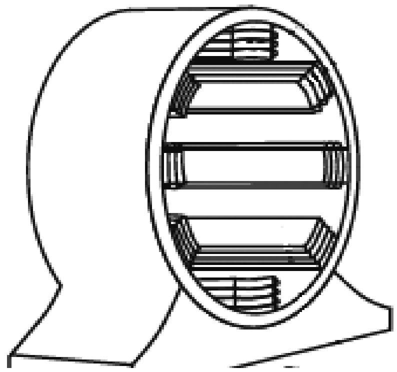


Figure2. 2 Stator

The rotor is the rotating part of the electromagnetic circuit. The most common type of rotor is the squirrel cage rotor. The rotor comprises of a cylindrical laminated core with axially placed parallel slots for carrying the conductors. Each slot carries a copper, aluminum, or alloy bar. The rotor of three-phase induction motors frequently is likewise implied as an anchor. The purpose behind this name is the anchor shape of the rotors used within quite early electrical devices. In electrical equipment the anchor's winding would be induced by the magnetic field, although the rotor takes this part in three-phase induction motors. figure 2.3 below show rotor

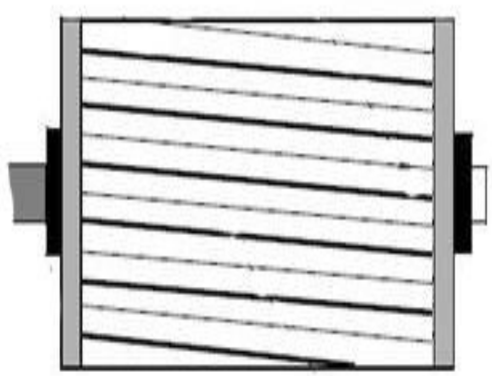


Figure2. 3 rotor

Induction motor has the same physical stator as a synchronous machine with an alternate rotor development. Induction motor might be worked as either motors or generator. On the other hand, they are fundamentally used as induction motors.

2.1.2 Types of Induction Motors

Single phase induction motor: The single-phase induction motor is not self-starting. When the motor is connected to a single-phase power supply, the main winding carries an alternating current. Three-Phase Induction Motor: These motors are self-starting and use no capacitor, start winding, centrifugal switch or other starting device. Three-phase AC induction motors are widely used in industrial and commercial applications. These are of two types, squirrel cage and slip ring motors. Squirrel cage motors are widely used due to their rugged construction and simple design. Slip ring motors require external resistors to have high starting torque. [8]

2.4 Programmable Logic Controller (PLC)

Programmable Logic Controller A Programmable Logic Controller, or PLC, is a ruggedized computer used for industrial automation. These controllers can automate a specific process, machine function, or even an entire production line. The PLC receives information from connected sensors or input devices, processes the data, and triggers outputs based on pre-programmed parameters Figure 2. show PLC Micro Logix 1100 controller

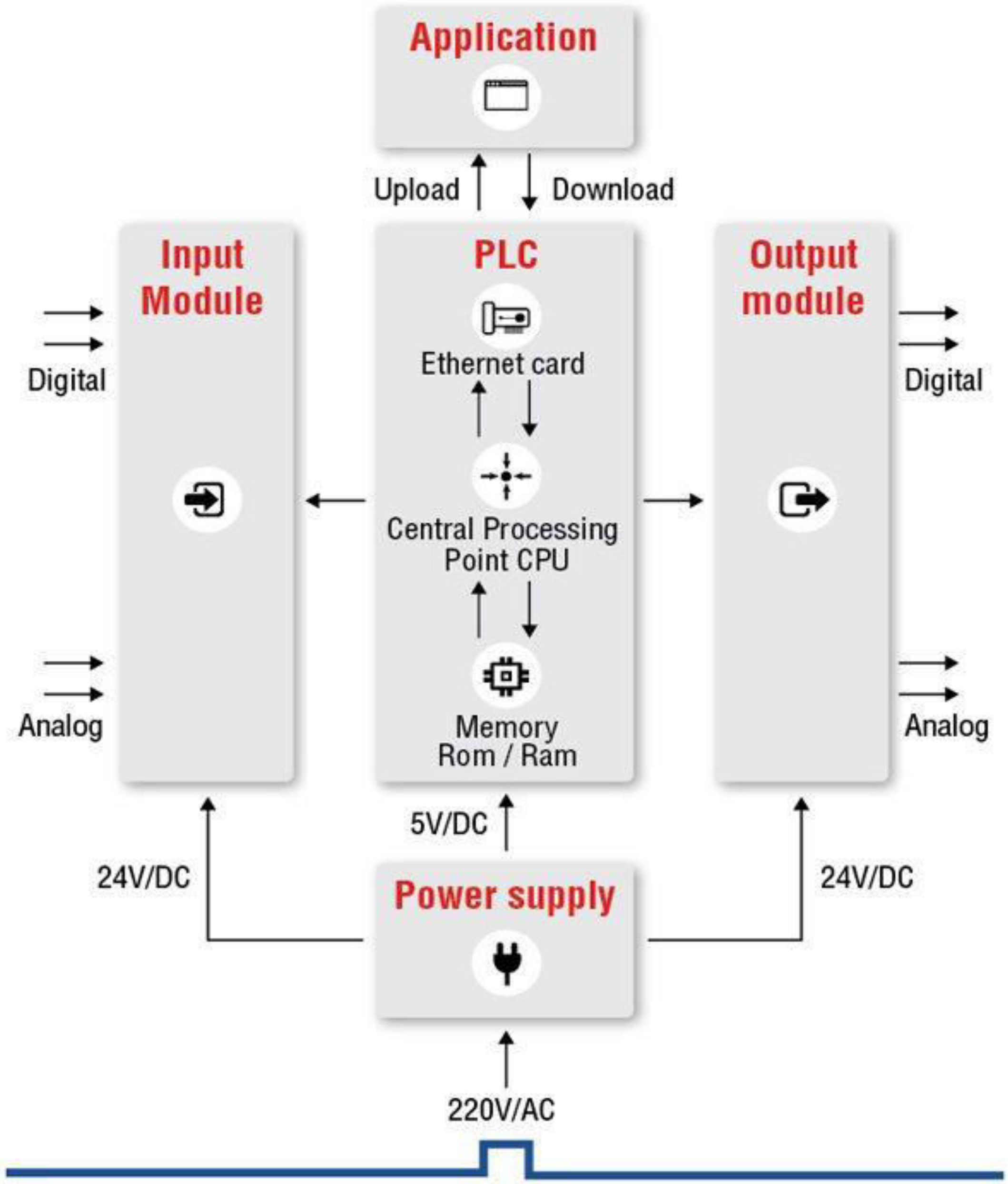
Figuer2.4 PLC Programmable Logic Controller

Depending on the inputs and outputs, a PLC can monitor and record run-time data such as machine productivity or operating temperature, automatically start and stop processes, generate alarms if a machine malfunctions, and more. Programmable Logic Controllers are a flexible and robust control solution, adaptable to almost any application. There are a few key features that set PLCs apart from industrial PCs, microcontrollers, and other industrial control solutions:

• I/O – The PLC's CPU Central Processor Unit stores and processes program data, but input and output modules connect the PLC to the rest of the machine; these I/O modules are what provide information to the CPU and trigger specific results. I/O can be either analog or digital; input devices might include sensors, switches, and meters, while outputs might include relays, lights, valves, and drives. Users can mix and match a PLC's I/O in order to get the right configuration for their application.

• Communications – In addition to input and output devices, a PLC might also need to connect with other kinds of systems; for example, users might want to export application data recorded by the PLC to a supervisory control and data acquisition (SCADA) system, which monitors multiple connected devices. PLCs offer a range of ports and communication protocols to ensure that the PLC can communicate with these other systems.

• Human Machine Interface (HMI) In order to interact with the PLC in real time, users need an HMI, or Human Machine Interface. These operator interfaces can be simple displays, with a text-readout and keypad, or large touch screen panels more similar to consumer electronics, but either way, they enable users to review and input information to the PLC in real time.



figuer2 5 PLC system

MicroLogix™ 1100 Programmable Logic Controller Systems add embedded EtherNet/IP™, on-line editing, and an LCD panel to the MicroLogix family. The built-in LCD panel shows controller status, I/O status, and simple operator messages. With 2 analog inputs, 10 digital inputs and 6 digital outputs, the MicroLogix 1100 controller can handle a wide variety of tasks.[9]

2.5 SCADA SYSTEM

SCADA stands for Supervisory Control and Data Acquisition. SCADA refers to a system that collects data from .various sensors at a factory, plant or in other remote locations and then sends this data to a central computer which then manages and controls the data. SCADA is a term that is used broadly to portray control and management solutions in a wide range of industries. One of key processes of SCADA is the ability to monitor an entire system in real time.. The main purposes for the use of a SCADA system would be to collect the needed data from remote sites and even the local site, displaying them on the monitor of the master computer in the control room, storing the appropriate data to the hard drive of the master computer and allowing the control of field devices (remote or local) from the control room. SCADA systems are equipped to make immediate corrections in the operational system, so they can increase the life-period of your equipment and save on the need for costly repairs. It also translates into man-hours saved and personnel enabled to focus on tasks that require human involvement [10]

2.6 Variable Speed Drive (VSD)

When an induction motor starts, it will draw very high inrush current due to the absence of the back EMF at start. This results in higher power loss in the transmission line and also in the rotor, which will eventually heat up and may fail due to insulation failure. The high inrush current may cause the voltage to dip in the supply line, which may affect the performance of other utility equipment connected on the same supply line. Adding a variable speed drive (VSD) to a motor-driven system can offer potential energy savings in a system in which the loads vary with time. VSDs belong to a group of equipment Figure 2.6below show variable frequency derive

figer2.6 Variable speed Drive (VSD)

called adjustable speed drives or variable speed drives. that have a safety factor. This often leads to energy inefficiency in systems that operate for extended periods at reduced load. The ability to adjust motor speed enables closer matching of motor output to load and often results in energy savings

The components of the drive system are broken into four major categories: source power, rectifier, dc bus, and inverter. Other components exits such as resolver and encoder feedback devices, tachometers, sensors, relays and help supplement the system.. First, the source power must be converted from alternating current to direct current. This conversion is accomplished by means of a rectifier; a diode is used for more intelligent rectification. The power source that was 460volts ac, 60 Hertz now converted to 650 volts dc. This AC to DC conversion is necessary before the power can be changed back to AC at a variable frequency.

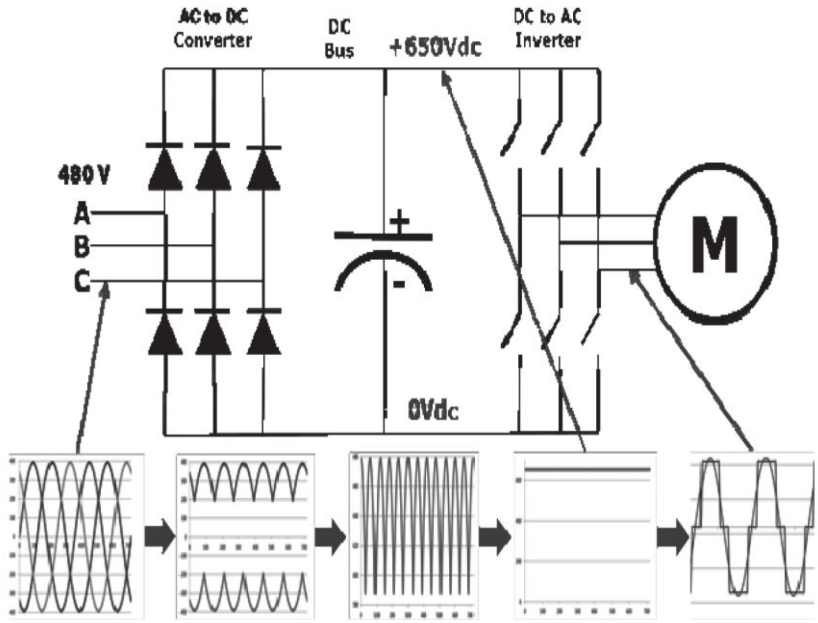


Figure2.7 the change of the VSD frequency

The diode bridge converter that converts AC-to-DC is sometimes just referred to as a converter. The converter converts the dc back to ac is also a converter, but to distinguish it from the diode converter, it is usually referred to as an inverter. It has become common in the industry to refer to any DC-to-AC converter as an inverter PowerFlex® 4 AC Drives are designed to meet global OEM and end-user requirements for simplicity, space savings, and cost efficiency. These compact drives provide intuitive features such as an integral keypad with local potentiometer and control keys that are active right out of the box.[11]

2.7 Phase Failure Relay

The Phase Failure Relay is a phase-voltage-balance monitoring device designed for use with magnetic controls to automatically prevent three phase motors or other equipment from operating or attempting to start up under open phase or single-phase conditions, thereby eliminating burnouts and consequent down-time frequently incurred by phase failure.. Figure2.8 show the phase failure

Figure 2. 8 phase failure

Phase Failure Relay is not a thermal device. It operates on the principle of phase voltage unbalance which may occur in a three phase system. It also protects against phase loss. All Phase Failure Relay models are listed with Underwriter Laboratories. Phase Failure Relay can be used to protect any magnetically controlled three phase equipment that would be damaged if subjected to abnormal phase conditions such as single phasing. It is designed to monitor any three phase supply line, and can be used with any type of actuating controls such as push button stations, thermostats, pressure or float switches. It may also be used in a trip circuit utilizing manually operated starters in conjunction with shunt or capacitive trip devices. Typical applications are any three phase motor. Unattended motors, such as ventilation fans, Pumps, refrigeration equipment, air conditioning units, welders and computers.

2.7.1 Operation of phase failure

Phase Failure Relay is a self contained power sensing device. In normal operation the incoming phases of the three phase voltage applied to our power-sensing network are in balance. When any phase becomes more than 12% unbalanced from the other two (either low or high), or a phase loss occurs, the sensing network will deliver an output voltage to activate the transistor circuit. This will cause the master output relay on the Phase Failure Relay to trip (either dropout or pickup depending upon model). A time delay of approximately 1 ½ seconds is incorporated to eliminate the possibility of nuisance tripping.. [12]

2.8 Proximity Sensor

The maximum distance that this sensor can detect is defined nominal range. Some sensors have adjustments of the nominal range or means to report a graduated detection distance. Proximity sensors can have a high reliability and long functional life because of the absence of mechanical parts and lack of physical contact between sensor and the sensed object. figer2 9 shown Proximity Sensor

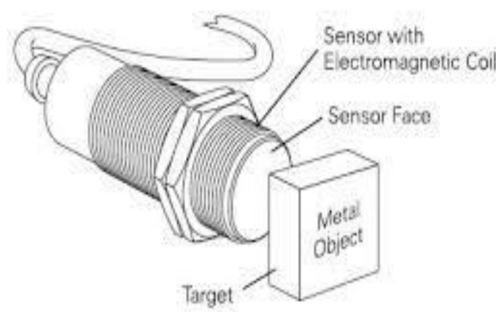


Figure2 1 Proximity Sensor

The proximity sensor on most smart-phones with touch screen exists to disable accidental touch events. The most common scenario is the ear coming in contact with the screen and generating touch events, while on a call. The simplest proximity sensors do not measure distance. A bumper can be passive, simply making the robot bounce away from things it hits. More often, a bumper has a switch that closes when it makes contact, sending a signal to the controller causing the robot to back away. When whiskers hit something, they vibrate. This can be detected, and a signal sent to the robot controller.[13]

2.9 Digital temperature Controller

A temperature controller is an instrument used to control temperature calculating the difference between a set point and a measured temperature. The controller takes an input from a temperature sensor and has an output that is connected to a control element such as a heater or fan.

Figure2. 2 Digital temperature Controller

To accurately control process temperature without extensive operator involvement, a temperature control system relies upon a controller, which accepts a temperature sensor such as a thermocouple or RTD as input. It compares the actual temperature to the desired control temperature, or set point, and provides an output to a control element. The temperature controller or thermostat is one part of the entire control system, and the whole system should be analyzed in selecting the proper equipment.[12]

2.9.2 Thermocouple

A thermocouple is a sensor for measuring temperature. This sensor consists of two dissimilar metal wires, joined at one end, and connected to a thermocouple thermometer or other thermocouple-capable device at the other end. When properly configured, thermocouples can provide temperature measurements over wide range of temperatures figuer2 .11 show Thermocouple

Figuer2. 3 Thermocouple

2.19 Level control device

A level sensor is a device for determining the level or amount of fluids, liquids or other substances that flow in an open or closed system. There are two types of level measurements, namely, continuous and point level measurements. Continuous level sensors are used for measuring levels to a specific limit, but they provide accurate results. Point level sensors, on the other hand, only determine if the liquid level is high or low. The figer2 12 Level control device

Figure 2. 4 Level control device

. The level sensors are usually connected to an output unit for transmitting the results to a monitoring system. Current technologies employ wireless transmission of data to the monitoring system, which is useful in elevated and dangerous locations that cannot be easily accessed by common workers. Applicable for Electrically Conductive (Sensitive) liquid like water and Electrically Non-Conductive liquid like diesel, oil etc. input sensor for conductive liquid, use a three sensing electrode [High (H), Low (L), Ground (G)] of suitable electrically Conductive metal (like stainless steel) and non-Conductive liquid, use a two set (High (H) & Low (L) of float type magnetic reed switch sensor. liquid Sensing to relay tripping time delay is less than 1 sec.[14]

Electrode Maximum Voltage : 24 VAC & Current : 1 mA (50/60 Hz)Galvanic isolation via transformer. figure

Relay Output : One Change over (1CO), 5A @ 230VAC/28VDC resistive load.

Figure 2. 5 Electrode

2.12 Photo sensor

A photoelectric sensor emits a light beam (visible or infrared) from its light-emitting element .A reflective-type photoelectric sensor is used to detect the light beam reflected from the target. A thru beam type sensor is used to measure the change in light quantity caused by the target crossing the optical axis.

2.12.1 Principle and major types

A beam of light is emitted from the light emitting element and is received by the light receiving element.

- Reflective model

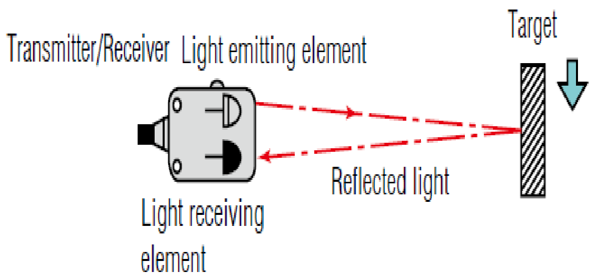


Figure 2. 6 Reflective model

- Both the light emitting and light receiving elements are contained in a single housing. The sensor receives the light reflected from the target.
- Thru beam model

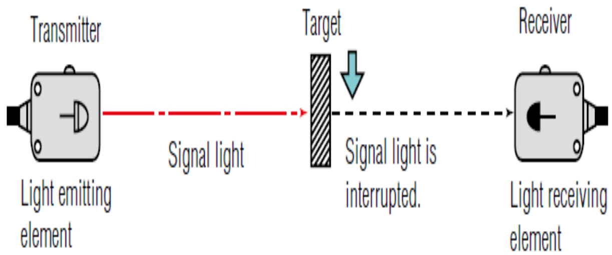


Figure 2. 7 Thru beam model

- The transmitter and receiver are separated. When the target is between the transmitter and receiver, the light is interrupted.
- Rotor effective model

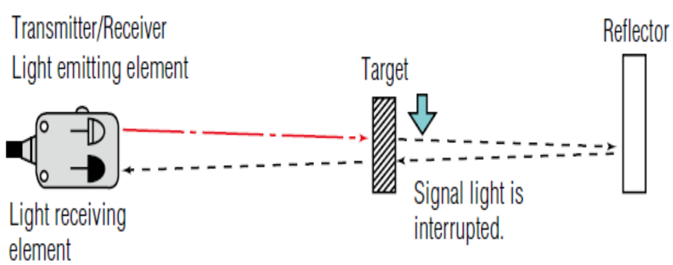


Figure 2. 8 Rotor effective model

- Both the light emitting and light receiving elements are contained in same housing. The light from the emitting element hits the reflector and returns to the light receiving element. When a target is present, the light is interrupted. [16]

2.13 Control Valve

A control valve is a valve used to control fluid flow by varying the size of the flow passage as directed by a signal from a controller ,This enables the direct control of flow rate and the consequential control of process quantities such as pressure, temperature, and liquid level. figer2 17 show control valve

Figure 2. 9 control valve

2.13.1 Operation of control valve

Air-actuated control valves each with a 4-20 mA "I to P" converter integral to a valve positioner. In this example each positioner is comparing the valve stem travel against control signal, and applying any correction

Figure 2. 10 Operation of control valve

.The opening or closing of automatic control valves is usually done by electrical, hydraulic or pneumatic actuators. Normally with a modulating valve, which can be set to any position between fully open and fully closed, valve petitioners are used to ensure the valve attains the desired degree of opening. .Air-actuated valves are commonly used because of their simplicity, as they only require a compressed air supply, whereas electrically-operated valves require additional cabling and switch gear, and hydraulically-actuated valves required high pressure supply and return lines for the hydraulic fluid. .An automatic control valve consists of three main parts in which each part exist in several types and designs:

- Valve actuator - which moves the valve's modulating element, such as ball or butterfly.
- Valve positioner - Which ensures the valve has reached the desired degree of opening. This overcomes the problems of friction and wear.
- Valve body - in which the modulating element, a plug, globe, ball or butterfly, is contained. [17]

2.14 Pump

Pump, a device that expends energy in order to raise, transport, or compress fluids. Figure2.19 below show pump

Figure 2. 11 pump

2.14.1 Classification Of Pumps

Pumps are classified according to the way in which energy is imparted to the fluid. The basic methods are

- volumetric displacement,
- addition of kinetic energy, and
- use of electromagnetic force.

A fluid can be displaced either mechanically or by the use of another fluid. Kinetic energy may be added to a fluid either by rotating it at high speed or by providing an impulse in the direction of flow. In order to use electromagnetic force, the fluid being pumped must be a good electrical conductor. Pumps used to transport or pressurize gases are called compressors, blowers, or fans. Pumps in which displacement is accomplished mechanically are called positive displacement pumps. Kinetic pumps impart kinetic energy to the fluid by means of a rapidly rotating impeller. Broadly speaking, positive displacement pumps move relatively low volumes of fluid at high pressure, and kinetic pumps impel high volumes at low pressure. A certain amount of pressure is required to get the fluid to flow into the pump before additional pressure or velocity can be added. If the inlet pressure is too small, cavitation (the formation of a vacuous space in the pump, which is normally occupied by liquid) will occur. Vaporization of liquid in the suction line is a common cause of capitation. Vapor bubbles carried into the pump with the liquid collapse when they enter a region of higher pressure, resulting in excessive noise, vibration, corrosion, and erosion.

The important characteristics of a pump are the required inlet pressure, the capacity against a given total head (energy per pound due to pressure, velocity, or elevation), and the percentage efficiency for pumping a particular fluid. Pumping efficiency is much higher for mobile liquids such as water than for viscous fluids such as molasses. Since the viscosity of a liquid normally decreases as the temperature is increased, it is common industrial practice to heat very viscous liquids in order to pump them more efficiently**.** [18]

2.15 The simulation programs

2.15.1 RSLinx

RSLinx is a windows based communication software package developed by Rockwell. Software to interface to all of the Rockwell and A-B industrial control and automation. hardware. RSLinx comes in a variety of different flavors including.RSLinx-Lite – PLC Programming software communication interface. It is the communications driver between the programming platforms (RSLogix) and the controllers themselves. RSLinx is only for Allen Bradely PLC programming[19] Figure 2.20 show the window of the RSLinx

Figure 2. 20 RSLinx

2.15.2 RSLogix

The RSLogix™ family of IEC-1131-compliant ladder logic programming packages helps you maximize performance, save project development time, and improve productivity. This family of products has been developed to operate on Microsoft Windows® operating systems. Supporting the Allen-Bradley SLC™ 500 and MicroLogix™ families of processors, RSLogix™ 500 was the first PLC® programming software to offer unbeatable productivity with an industry-leading user interface.. RSLogix 500 programming package is compatible with programs created with Rockwell Software DOS-based programming packages for the SLC 500 and MicroLogix families of processors, making program maintenance across hardware platforms convenient and easy[18] Figure 2.21 show the window of RSLogix

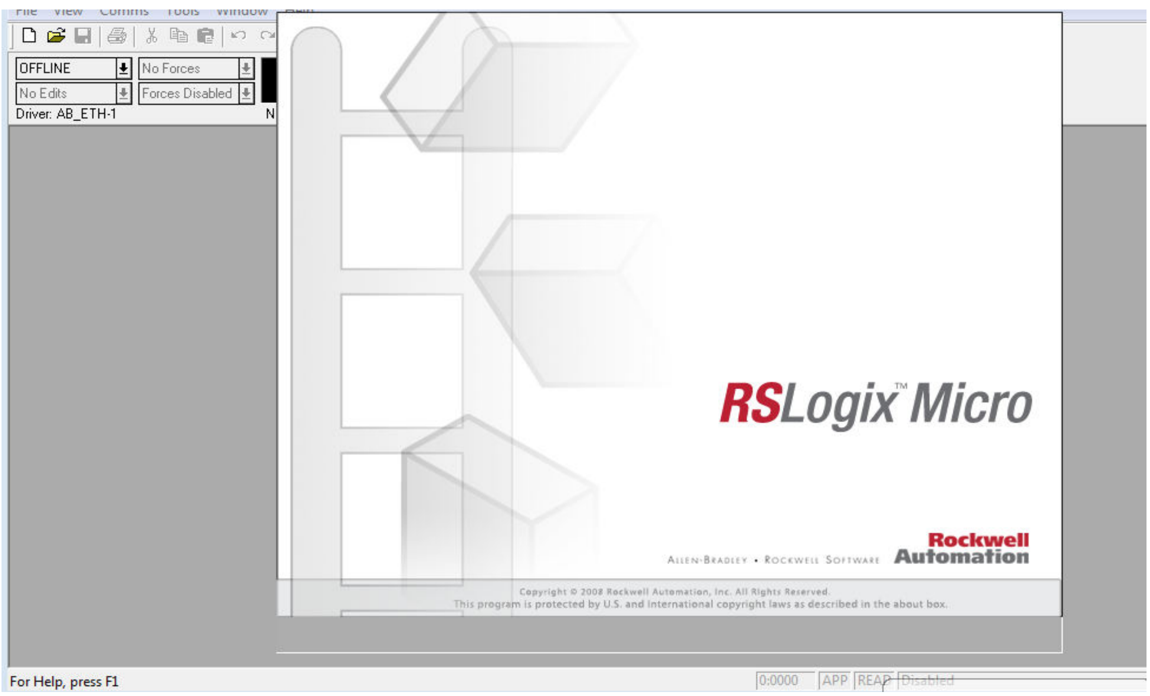


Figure 2. 21 RSLogix

2.15.3 In Touch

InTouch HMI enables users to quickly create and manage standardized, reusable industrial applications to maximize the return on engineering, shorten project times, more clearly inform operators, reduce risk and significantly lower total cost of ownership., Application Templates allow users to start the design of a new HMI application from a base template instead of starting from scratch, saving hours and hours of engineering. Application Templates can be as simple as a navigation framework or as rich as the user desires. System Integrators can reuse their engineering in multiple projects, OEMs can deliver base applications to their end users, and new users can get started in a shorter time. Application Templates can be selected via a template browser which provides a thumbnail preview of the templates. Users can organize Application Templates in a folder structure of their choice, by resolution, by industry, by customer, by engineering team, etc .A number of Application Templates are available out-of-the-box. Users can create their own application template Figure2.22 below show the window of InTouch program.[20]

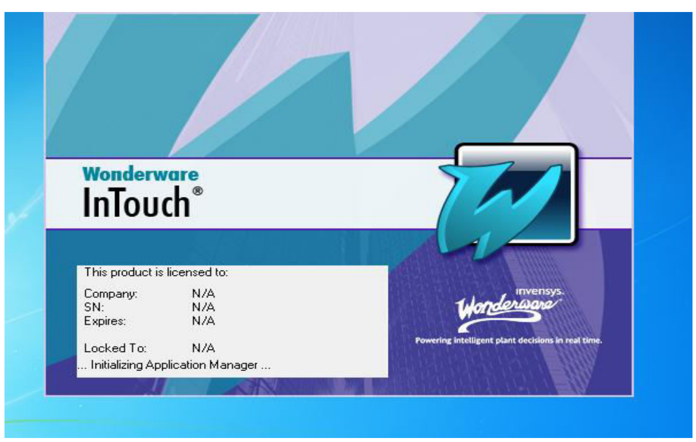


Figure 2.22 InTouch

2.15.4 AnyDesk

AnyDesk is a proprietary remote desktop tool distributed by AnyDesk Software GmbH. The software program facilitates remote access to personal computers running the host application, which can be installed on Windows, maces, Linux and FreeBSD. AnyDesk allows users to access said computers both from personal computers and from iOS and Android mobile devices. AnyDesk enables you to work remotely from wherever you are. Every time you need to access a remote screen, whether it is just across the office floor or on the other side of the world, you can use AnyDesk. Just start the downloaded AnyDesk.exe file and you are ready to go. Figure 223 show the window of AnyDesk.

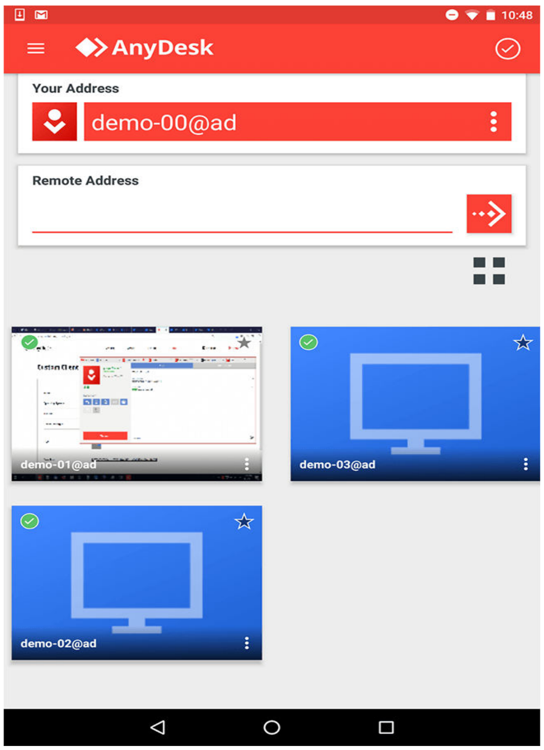


Figure 2. 23 AnyDesk

CHAPTER THREE

SYSTEM DESIGN AND OPRERATION

CHAPTER THREE

SYSTEM IMPLEMENTATION

3.1 Overview

This chapter is about describing the block diagram, flow chart and the description of the system design and operation design.

3.2 block diagram of the system

the block diagram deals with key components of the system. The digital computer is used as an interface between PLC and SCADA, Also consists of sensors that send the signals to the PLC unit as inputs ,The PLC is a microprocessor based system controller used to sense, activate and control industrial equipments , SCADA is a centralized system used to supervise a complete plant and basically consists of data accessing features and controlling processes remotely. The communication protocol used is Ethernet, The Variable Frequency Drive VFD connected to the PLC receives AC power and converts it to different frequency adjustable voltage output for controlling the three phase induction motor of the operation. also we can control and remote the hole process by smart phone through ANY DESK application which is connecting the smart phone and the pc by network the figure 3.1 show the block diagram

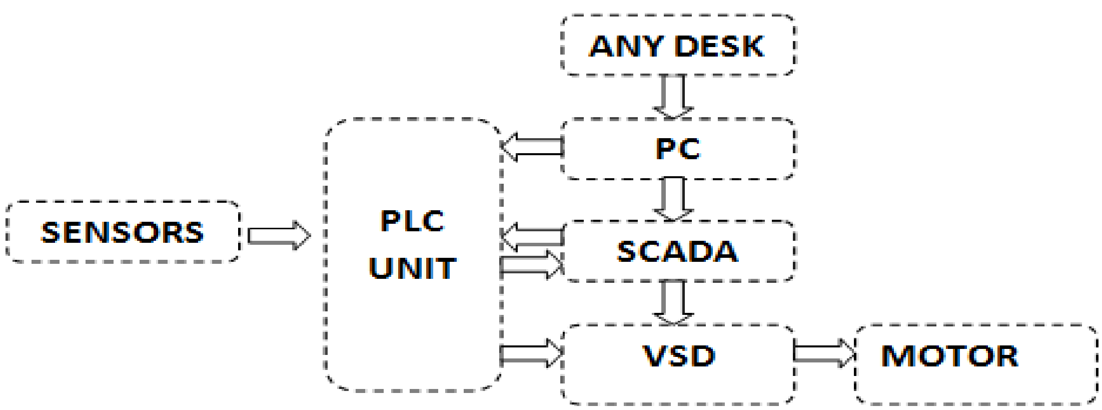


Figure 3. 1 block diagram

3.3 **flow Chart Of The System**

In this thesis there are two flow chart to present the system figure 3.2 is the flow chart1 that show controlling the speed of the induction motor that used in conveyer belt by VFD and figure 3.2 is the flow chart 2 that show the whole system process of the filling tank ,bottle and capping by PLC, SCADA

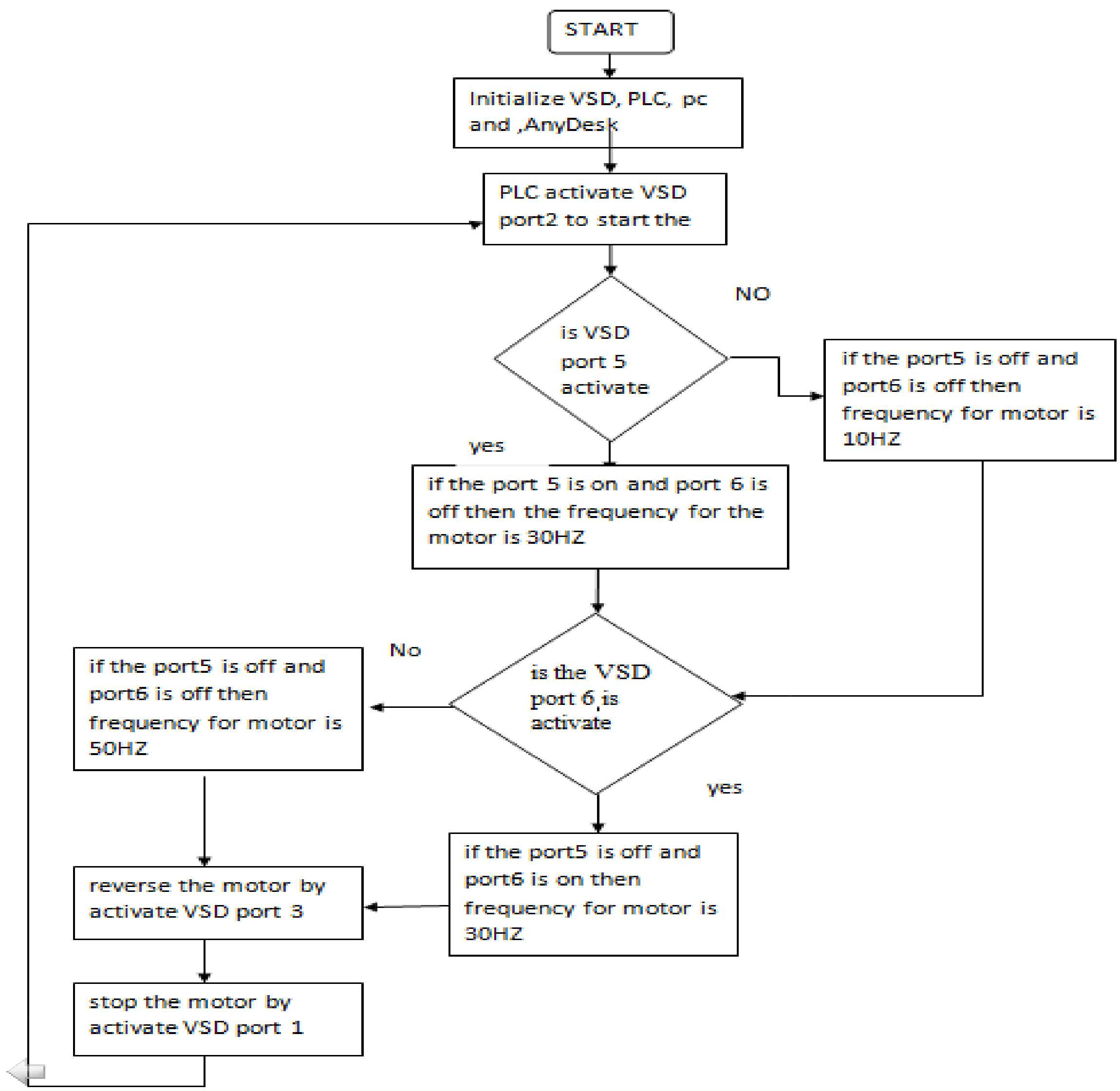


Figure 3. 2 flow chart 1 Controlling Induction motor

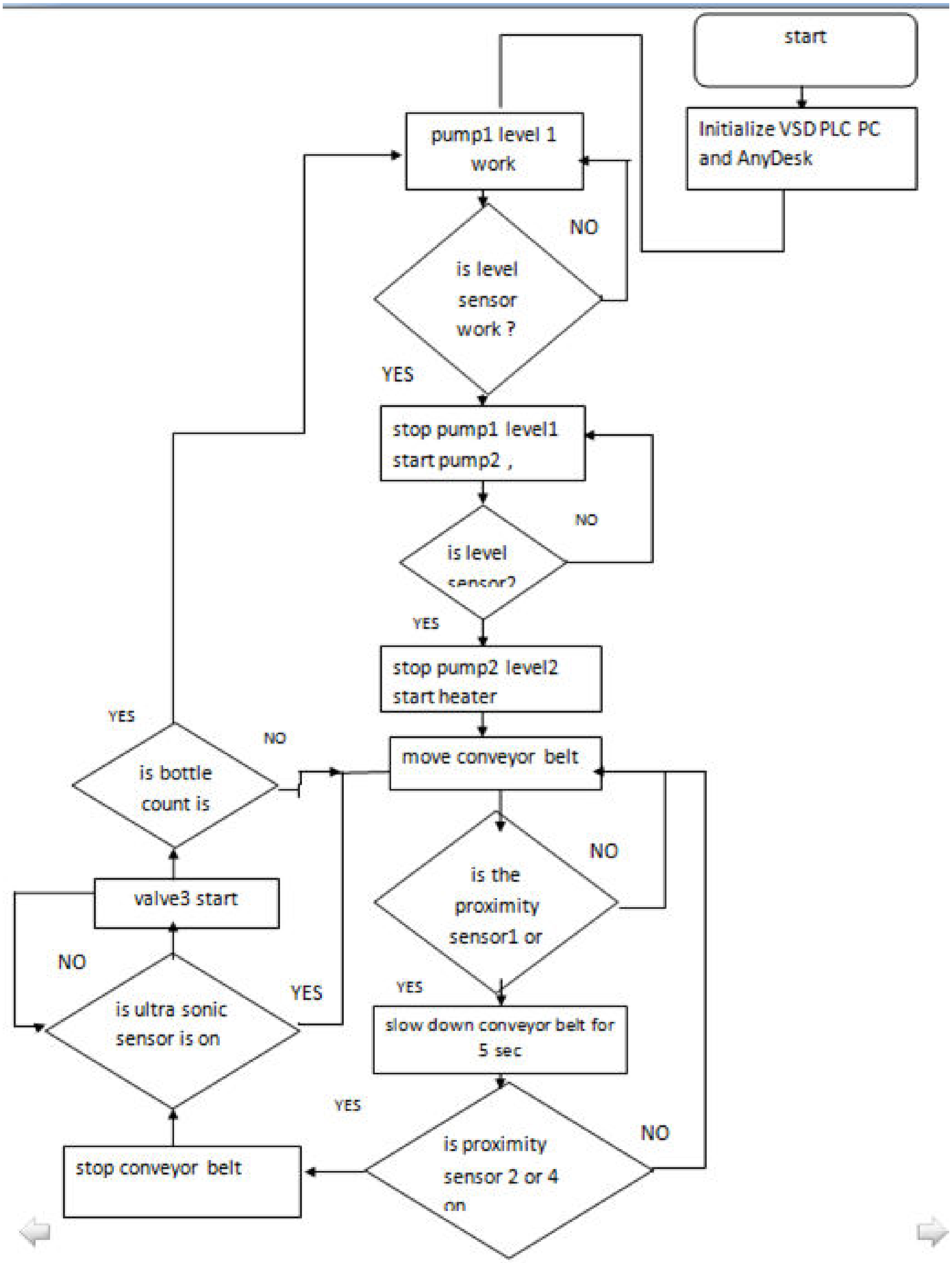


Figure 3. 3 Flow Chart 2 full system process

3.4 Description Of The System

the system is being installed using the following components:

- Three phase induction motor.
- Programmable logic controller PLC.
- Variable frequency deriver VFD.
- Phase failure
- Level control device.
- Temperature controller.
- 4 Proximity sensor.

3.5 Signal movement

the system is design as follow:

the phase failure, level control, temperature controller and the two proximity sensors are wiring to the plc inputs in respect which is

- Phase failure wiring with PLC from the Port 18 and the I/0 in the PLC the Port 16 is wiring to(+ 24)dc volt power supply.
- Level control wiring the Port 3 to the input I/1 in the PL and wiring the Port 2 to (+ 24)dc volt power supply.
- Temperature control wiring the Port 13 and 14 to the inputs I/2 ,I/3 in order also wiring the Port 15 to (+ 24)dc volt power supply .
- The proximity sensors are wiring the blacks wire to inputs I/4 ,I/5 in order also wiring the blue wire to (+ 24)dc volt power supply and brown wire to (-24)dc volt power supply .

The VFD wiring to the plc as follow:

- Port 1 (stop) in the VDF wiring to (+ 24)dc volt power supply .
- Port 2(start) in VFD wiring to the plc output O/2.
- Port 3 (reveres) in VFD wiring to the plc output O/3.

- Port 4 (digital common) in VFD wiring to (- 24)dc volt power supply.
- Port 5 (preset frequency)in VFD is wiring to the plc output O/4.
- Port 6 (digital input) in VFD is wiring to the plc output O/5.

Every (DC com) port in the PLC is wiring to (- 24)dc volt power supply.

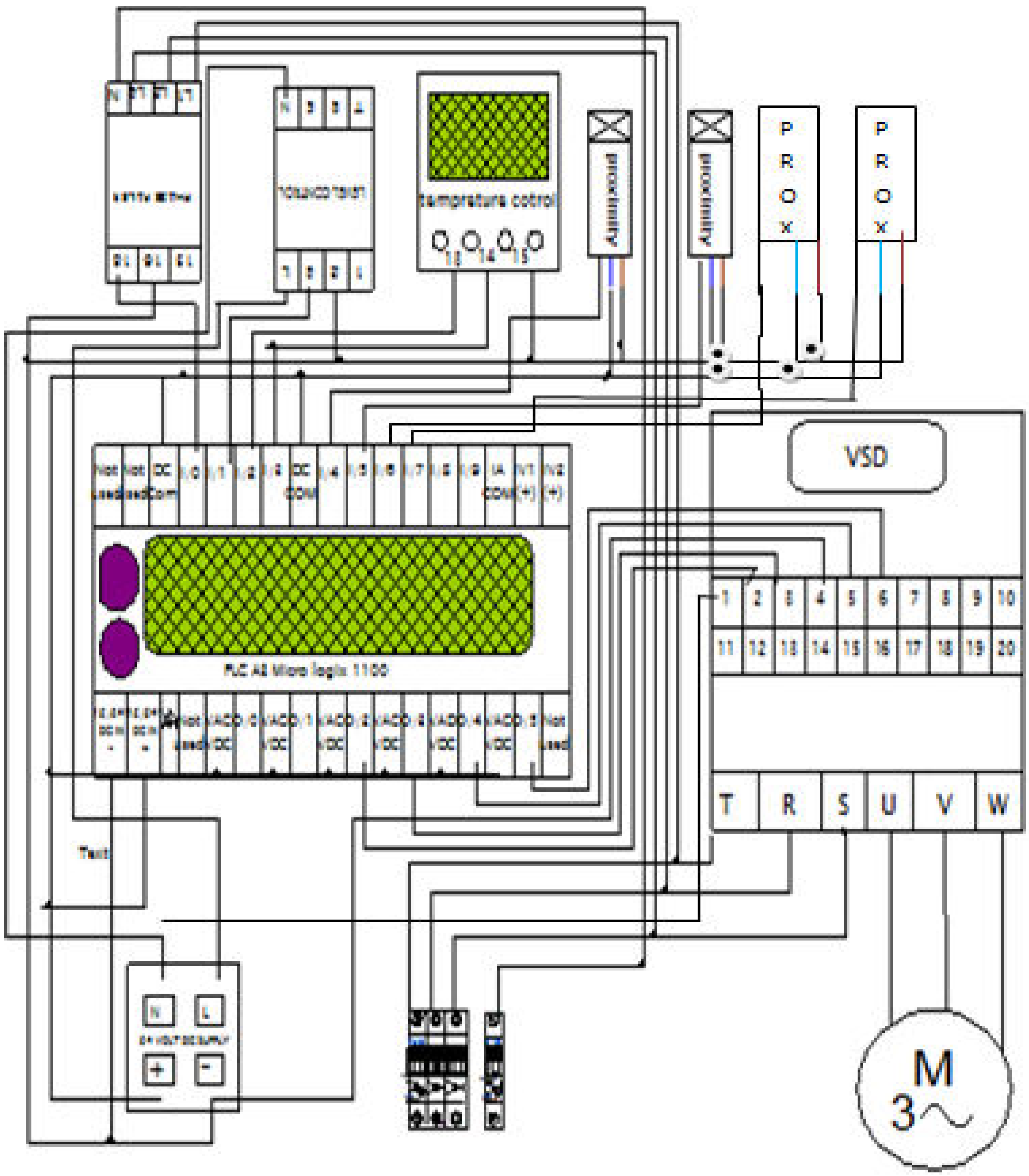


Figure3. 4the wiring design

3.6 SCADA System Design

in this SCADA design to control and monitoring automatic tank filling and backing process using PLC and SCADA system following .

- When the switch start pump1 and valve 1 will start to fill the tank by 50% when the water level reach the set point of the level sensor pump1 and valve1 well stop while pmup2 and level 2 will start to fill the tank by 50% also, when the tank is completely filled and water level reach the set point of the level sensor pump 2 and valve 2 well stop.
- After filling the tank the heater will start heating the liquid an tell the temperature sensor reach the set point then the heater will stop.
- At the same time of staring the heater the 3 phase induction motor also start moving the conveyer belt to move the bottle below valve three .
- When the proximity sensor 1 detect the bottle the motor slow down the speed by the VFD for some time and when the proximity sensor2 detect the bottle the VFD well stop the motor .
- Valve 3 will open when the bottle stop according to proximity sensor 2.
- The ultra sonic check if the bottle is quite full and send a signal to motor to start work again and when the bottle reach proximity sensor 3 the speed of the motor well slow down again to provide smooth stop when the bottle reach proximity senor 4
- The capping machine start according to proximity sensor 4 signal after 5 second the capping machine well stop and bottle moving
- The hole process repeat every 10 bottles .

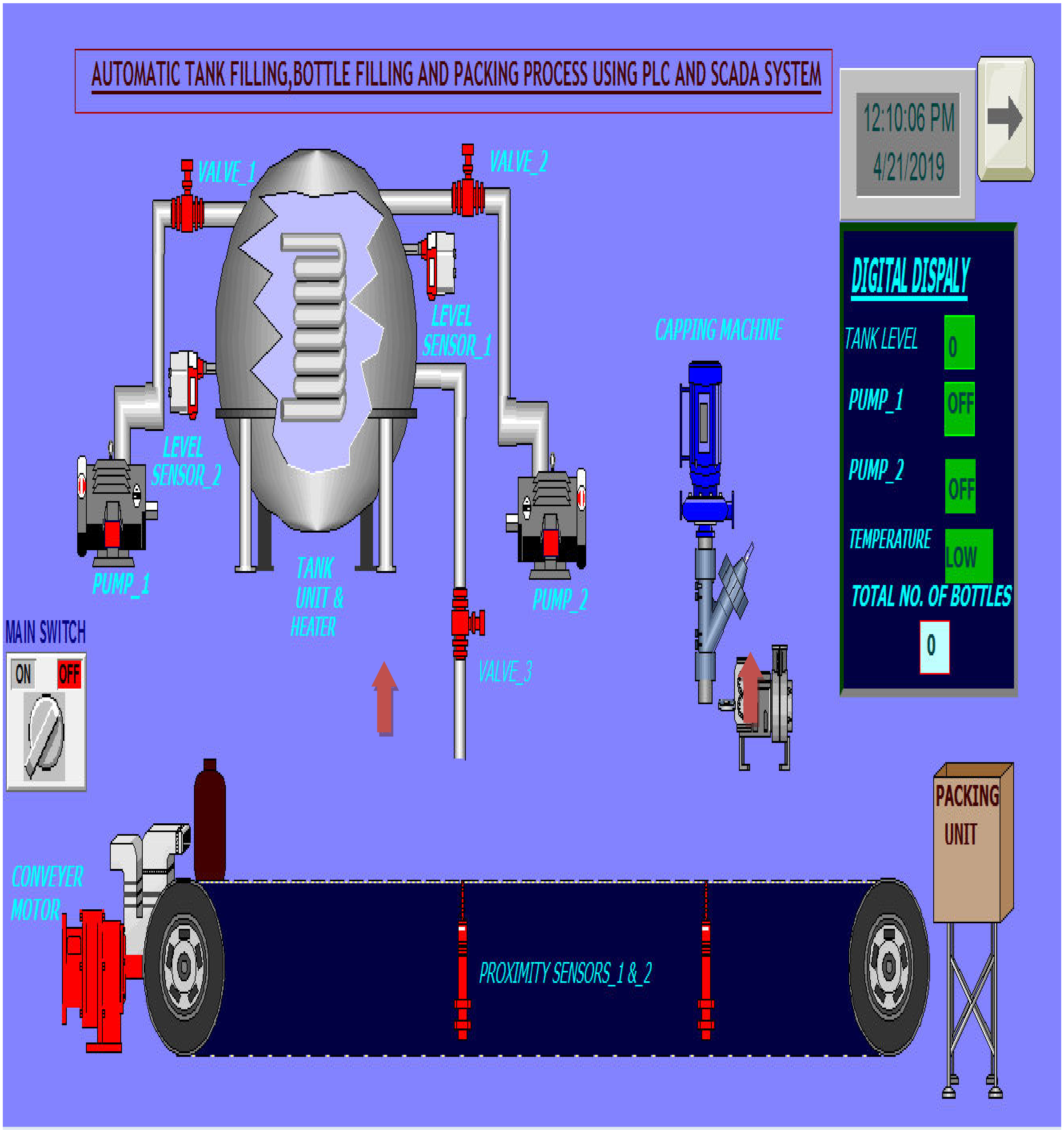


Figure 3.5 SCADA design for filling process

The figure below for monitoring the processes of the system the indicators, the safety and alarms

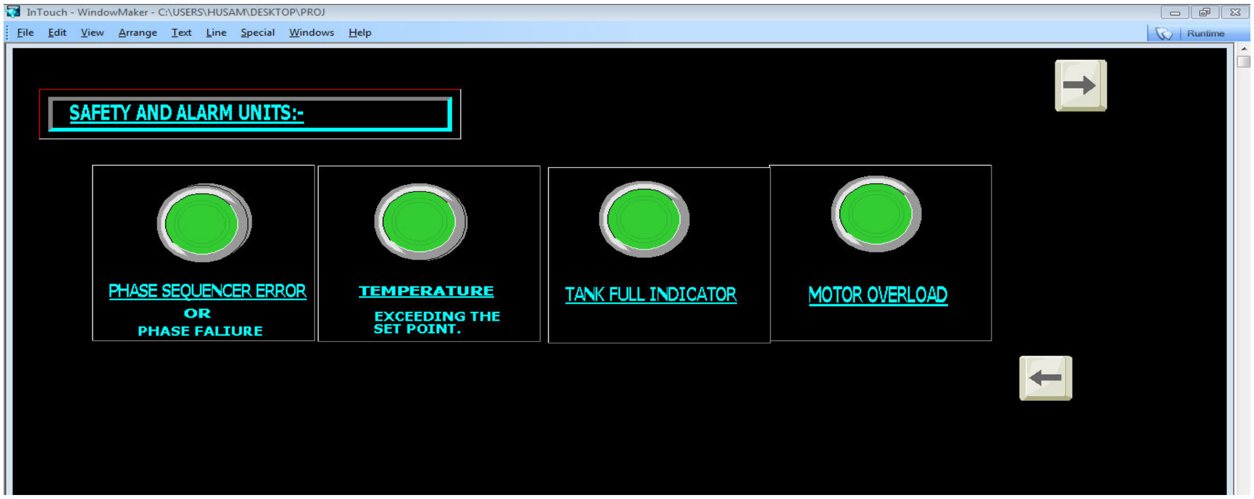


Figure3 .6 Safety and Alarm Unit

The figure is graphic show the tank level , temperature and the count of bottles

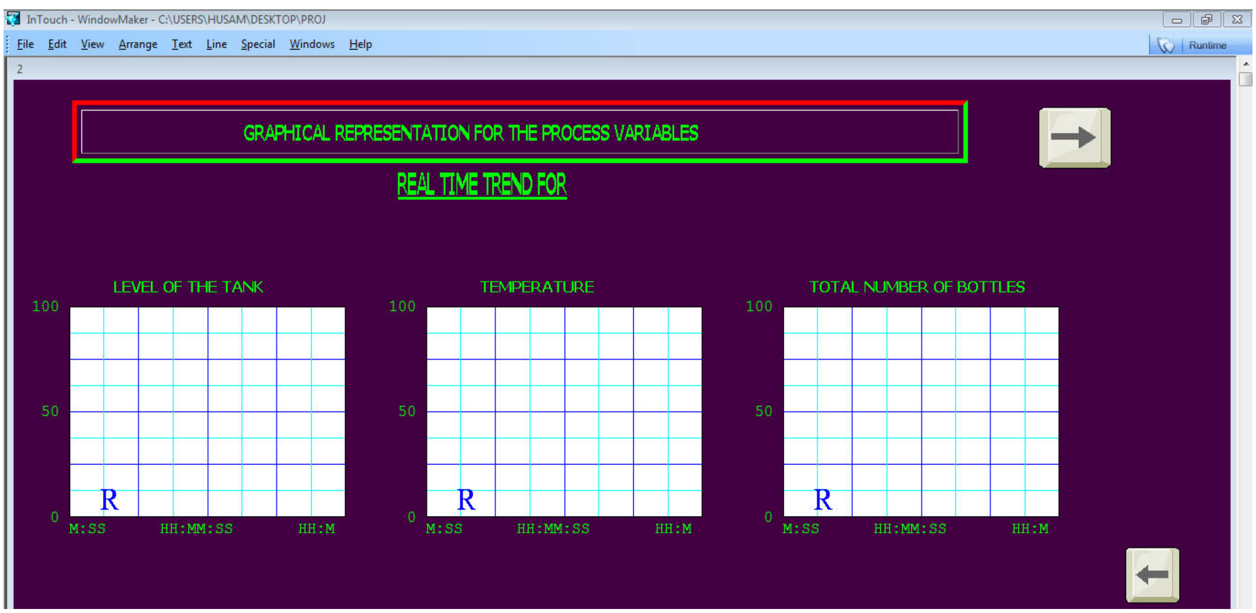


Figure 3 1 graphic representation for process variable

This figure show the window that can control the motor speed through the variable speed driver

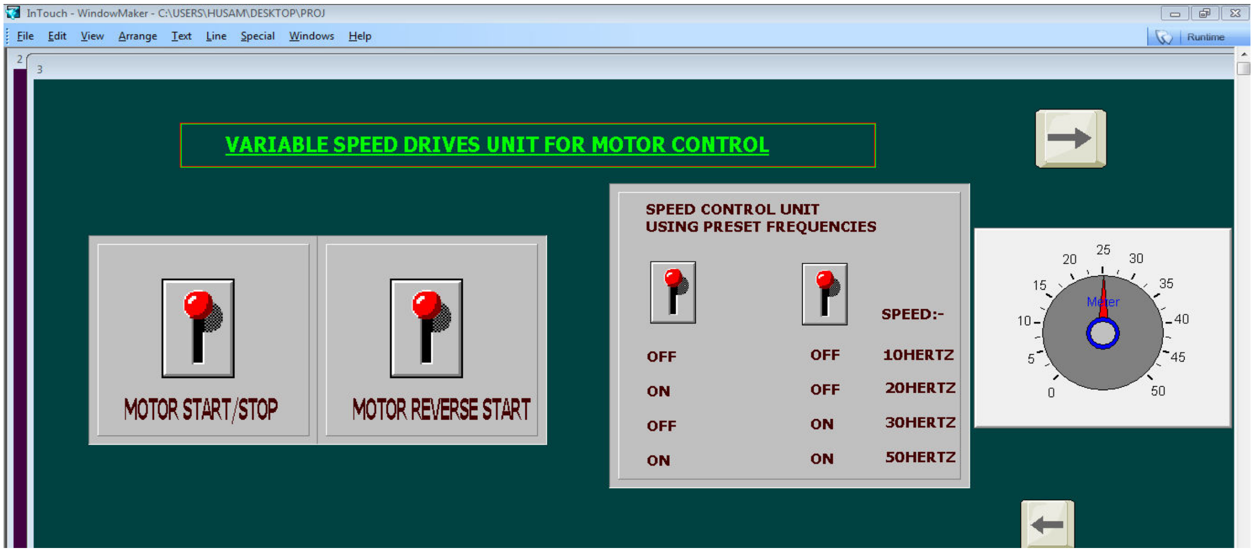


Figure 3. 2 Variable speed derive unit for motor control

the figure below is graphic show the motor frequency

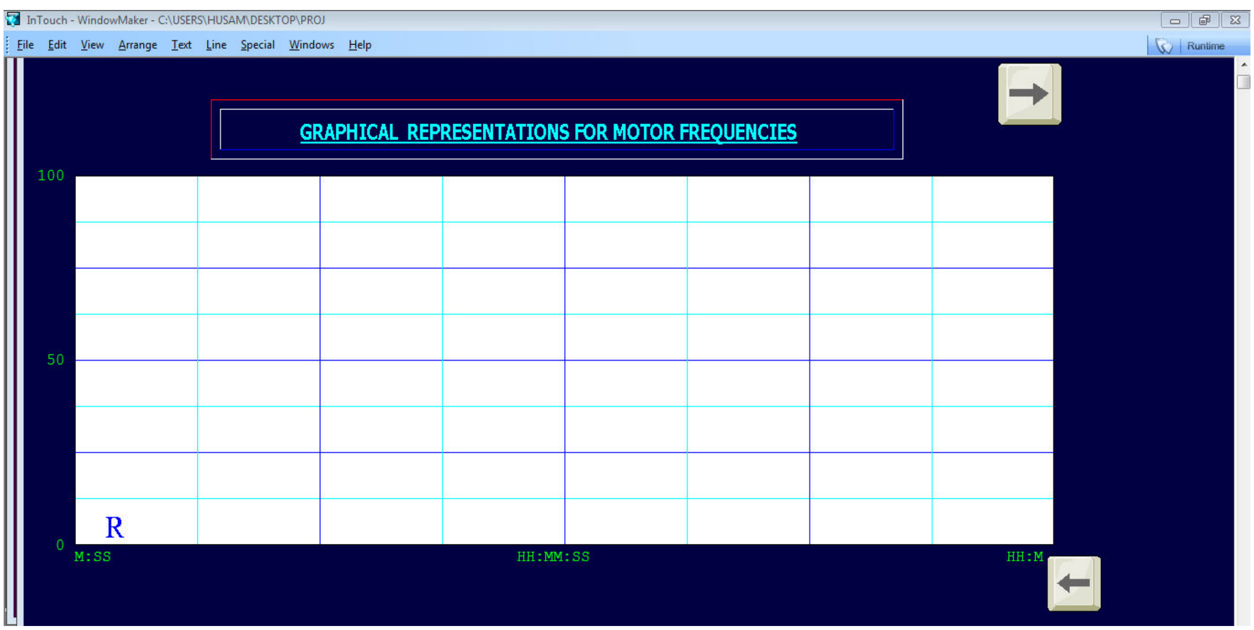


Figure 3 3 graphic representations for motor speed

3.7 The practical system connection and devise

As shown in Figure 3.9 the motor is connected to VSD by start -delta connection the VSD connected to the PLC as an outputs so the plc can control the VSD also connected a phase failure as a protection devise in case any phase get lose or there is a voltage drop in the three phase supply .The level control ,temperature control and the proximity sensors are connected to the input ports of the plc so when the system switch on the VSD resave the signal from the PLC to change the speed of the motor according the change of the signal of the proximity sensor .all this component can control and remote by SCADA system either through the pc or the smart phone

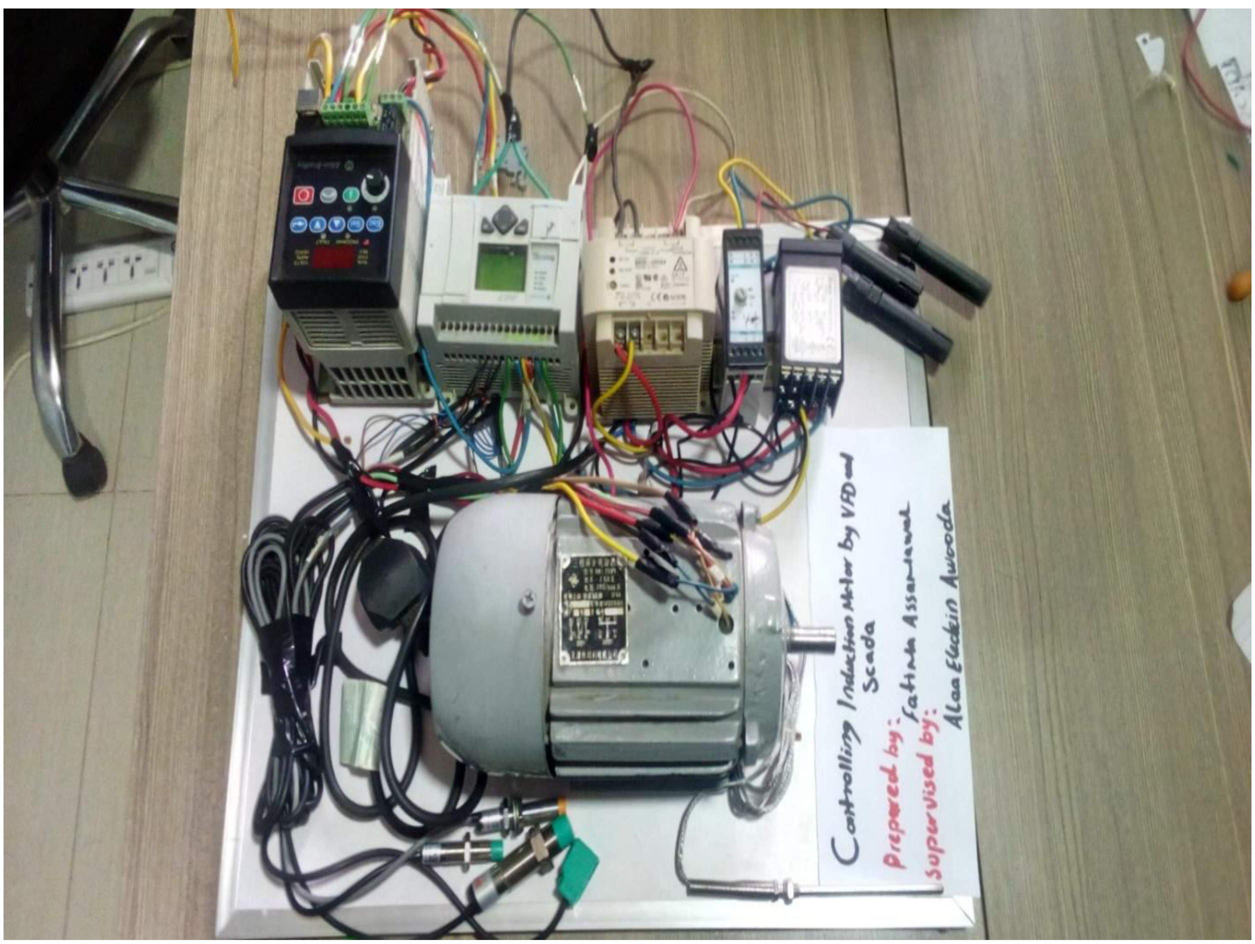


Figure 3. 9 the component of the practical part of the system

CHAPTER FOUR

RESULTS AND DISCUSSTION

CHAPTER FOUR

System Simulation Results and Discussions

4.1 Overview

After programming the system it must save and compile the errors, if there is an error program must be corrected, then export it to step7- 300 simulators to test it and show the results. This section discus all outputs reactions which happened according to specific actions have given to the inputs before. These reactions made the outputs either active or not active, in another word either on or off. Changing outputs situations happen immediately or may take time because major of inputs depend on timers

4.2 The simulation Program

4.2.1 SCADA System Using InTouch

The SCADA system design by InTouch program. this simulation has 5 window as shown in figure 4.6.a window 1 included two parts the first part is about tank filling and heater, this part contain of 2 pumps and 2 valve to filling the tank also there are 2 level control to measure the level of the liquid in the tank and temperature sensor to control the heater .

The second part is the conveyer belt which contain of motor to move the conveyer belt ,4 proximity sensors to detect the position of the bottle, photo sensor to check if the bottle s full and capping machine .this window also has a digital display that show tank level percentage , pumps mood, temperature mood and counter to count the bottle that get packing, Also main switch to operate the system .

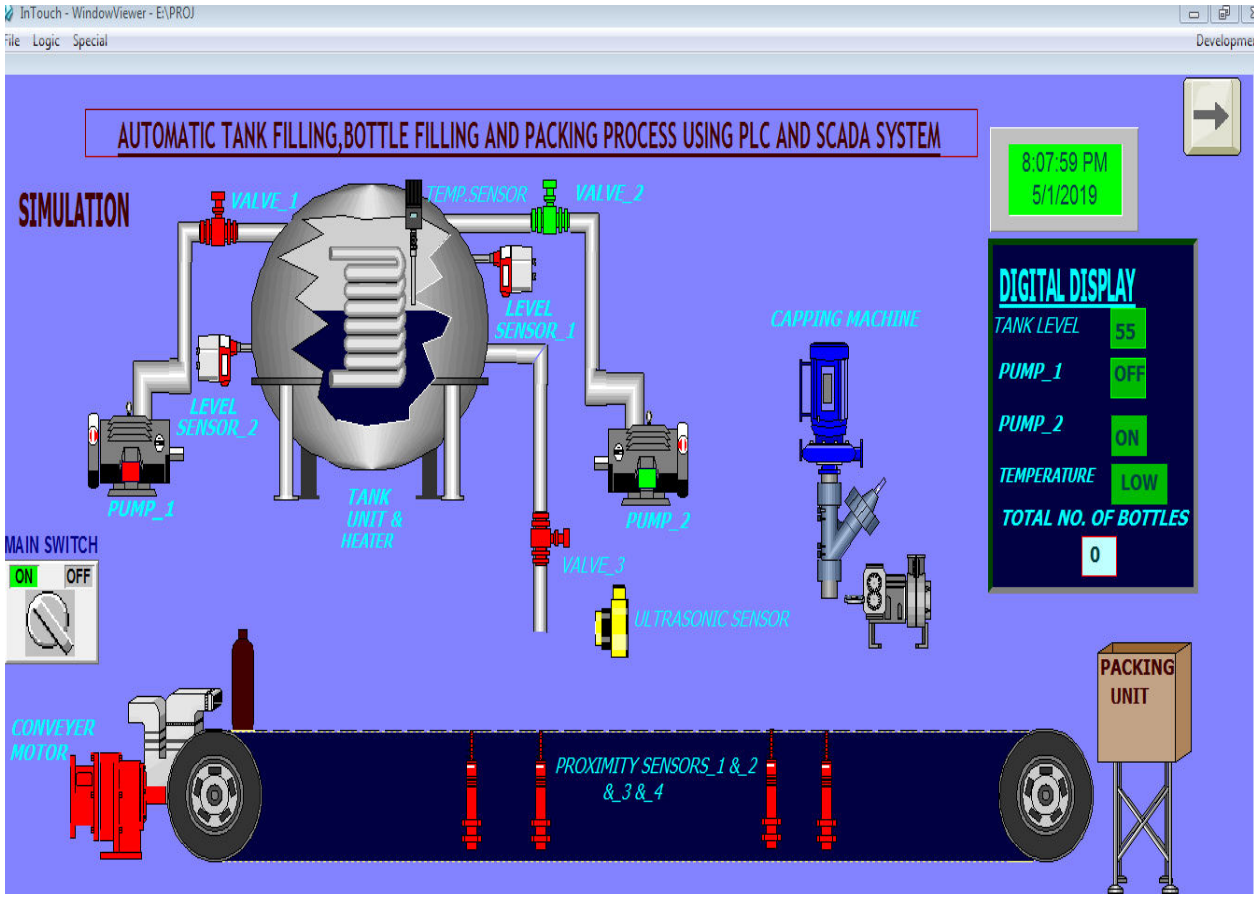


Figure 4.1 a Automatic system position1

Figure .7.b ,figure 4.7.c and figure 4.7.d shows the different position of the bottle which according to the proximity sensors and photo sensor signals the VSD control start, stop and the speed of the induction motor that move the conveyer belt

in the figure 4.7.b the bottle was in the start position and its move when the pump2 stop working which the level sensor1 send a signal when the tank full to stop the pump2 ,valve 2 and to operate the motor by sending signal from the VSD (port2) to start the motor to move the bottle. When the bottle detected by proximity sensor 1 the speed of the VSD (port 5) send a signal t decrease the the speed of the motor as shown in figure 4.7.b

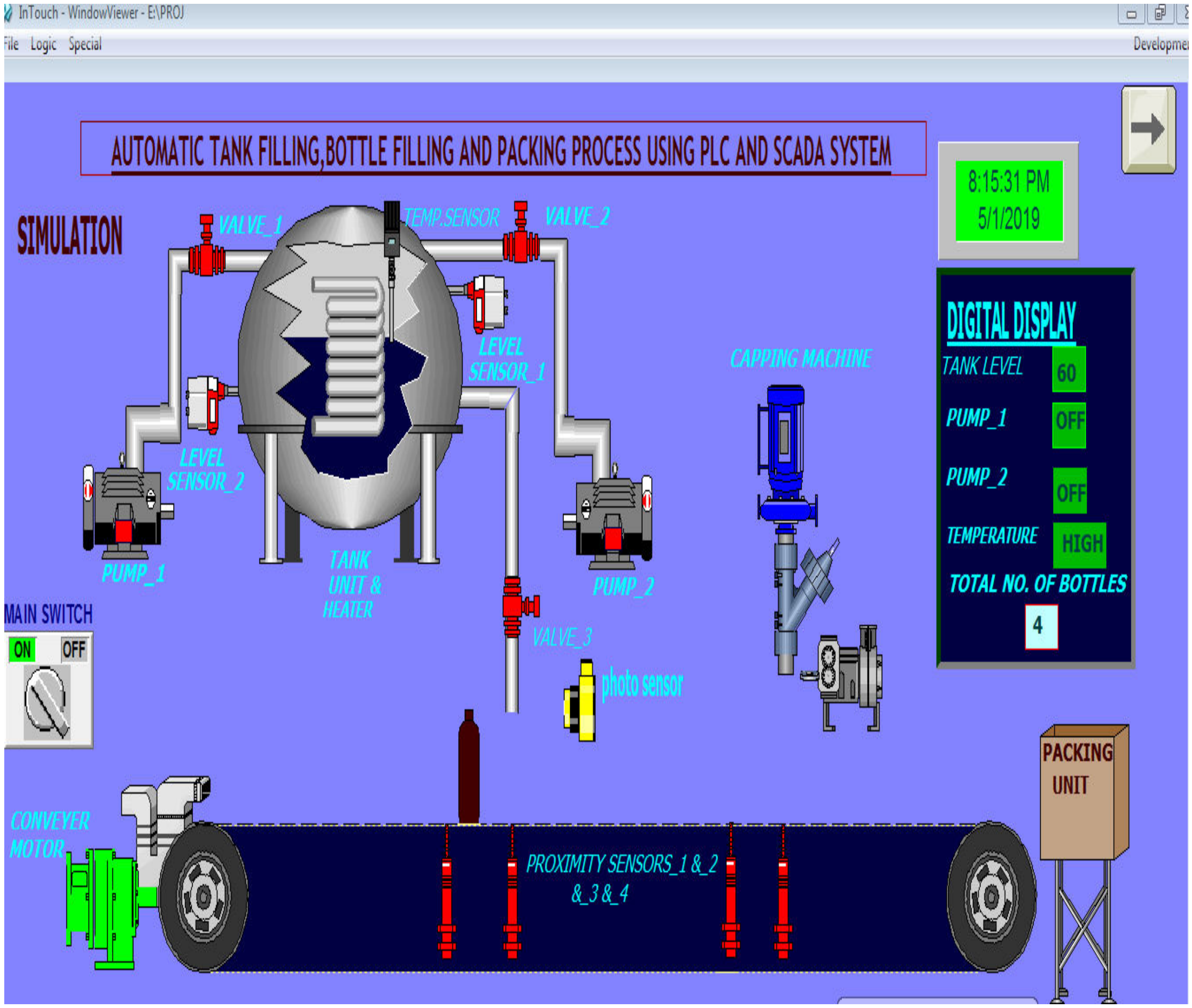


Figure 4.1 b Automatic system position2

And when the bottle detected by proximity sensor 2 the VSD (port1) send a signal to the motor to stop moving the valve 2 open and fill the bottle it as show in figure 4.7.c after the bottle full the photo sensor send signal to VSD (port2) to tart the motor again to move the bottle and When the bottle reach proximity sensor 3 the VSD (port 5) decrease the motor speed .

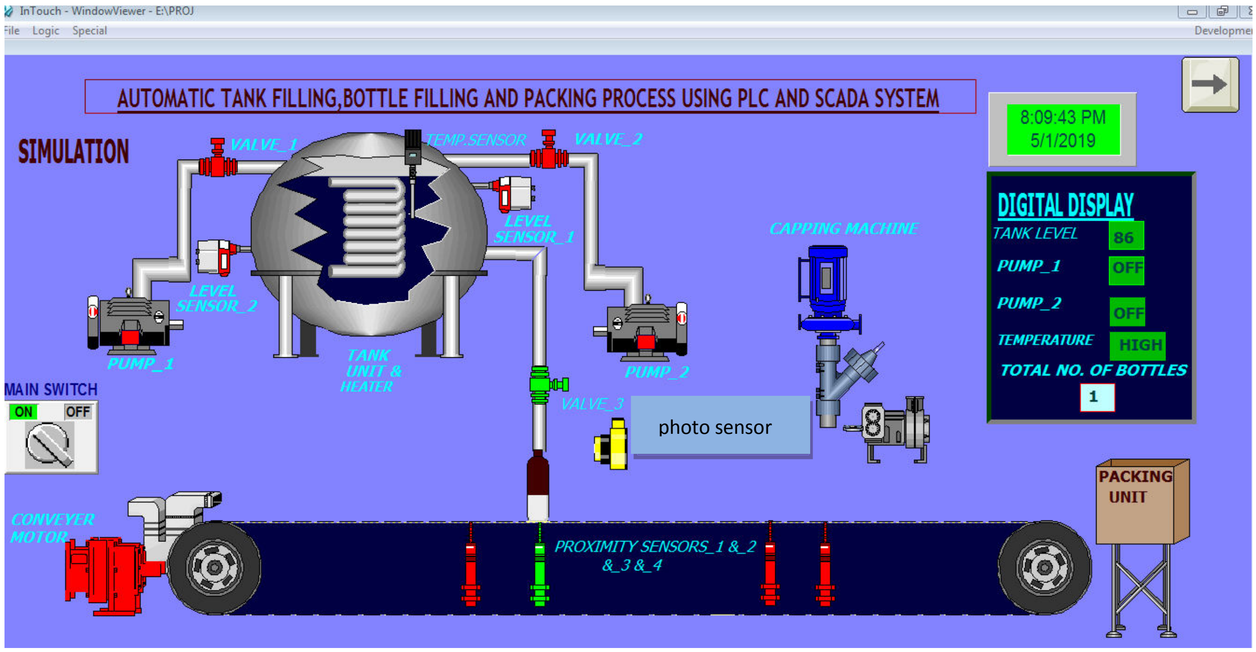


Figure 4.1 c Automatic system position3

The bottle stopped again in the position of proximity sensor 4 to get capping by the capping machine and then the motor start to move the bottle to the packing unit and the process of filling bottle start again antel the count complete ten bottles then the tank start filling again

.

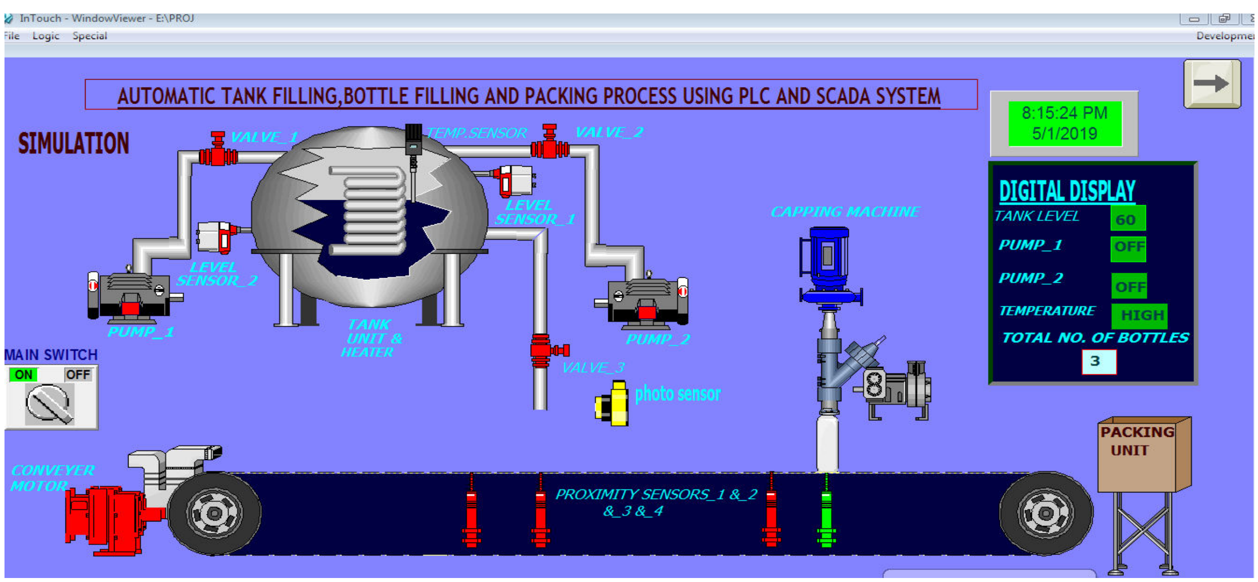


Figure 4.1 d Automatic system position 4

Figure 4.8.a , figure 4.8.b and figure 4.8.c are show the graphical presentation for the process variable, the first graph in the left present the level of the tank in the filling process as shown in figure 4.8.a. The second graph present the total number of bottles when the tank ful the bottle start filling as shown figure 4.8.b and c so the number of bottle start increase while the level of the tank will decrease.in thes graphs the axel x present the time

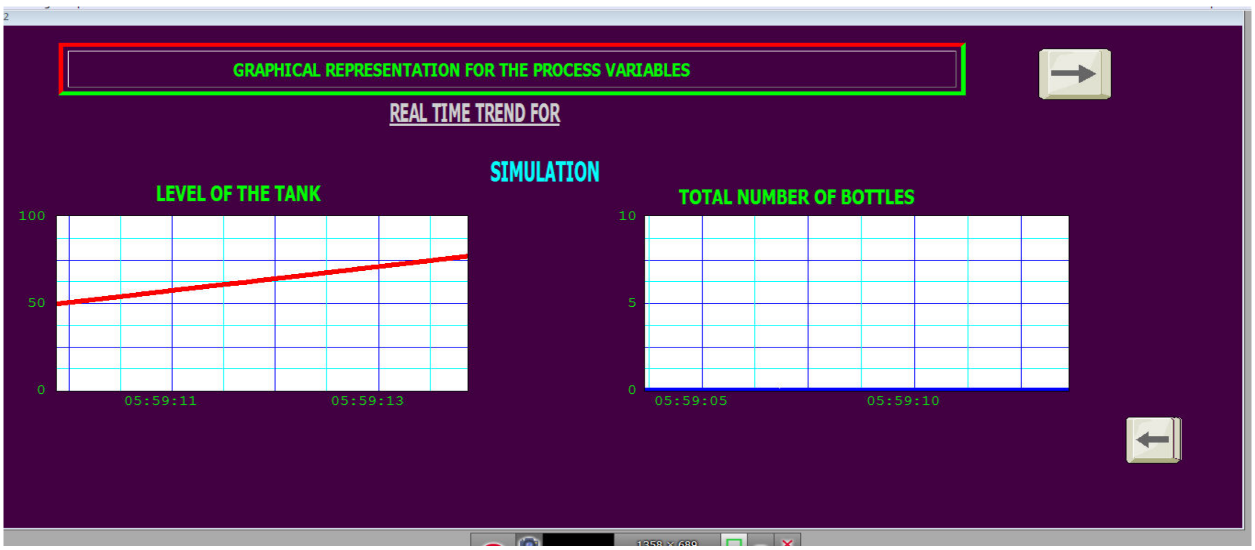


Figure 4.2 a graphic for tank and no. of bottle case1

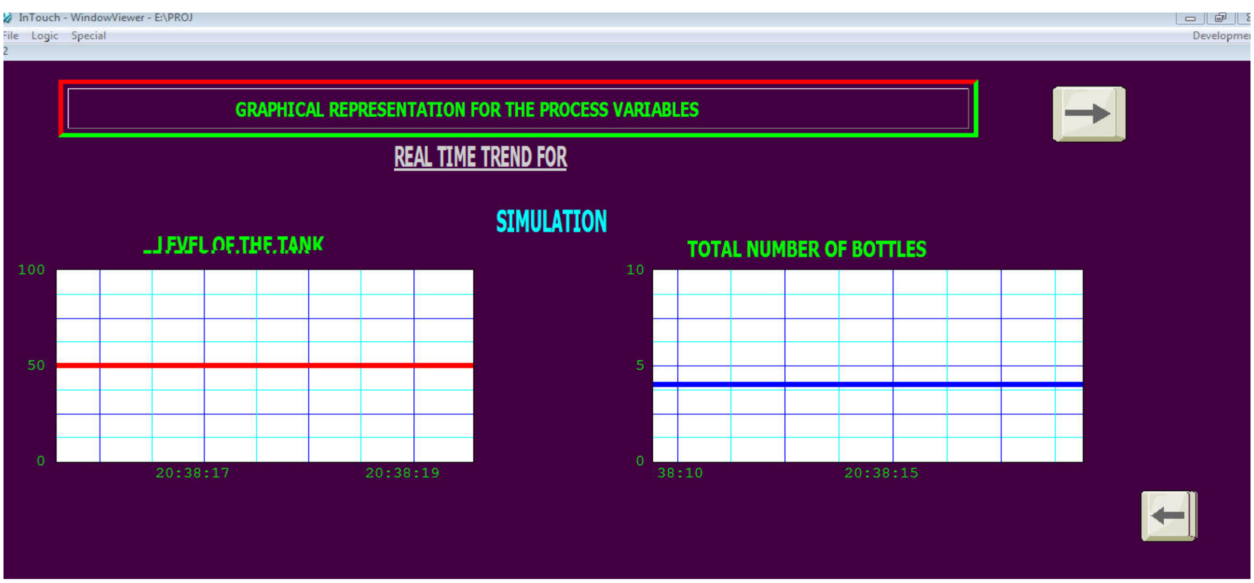


Figure 4.2 b graphic for tank and no. of bottle case2

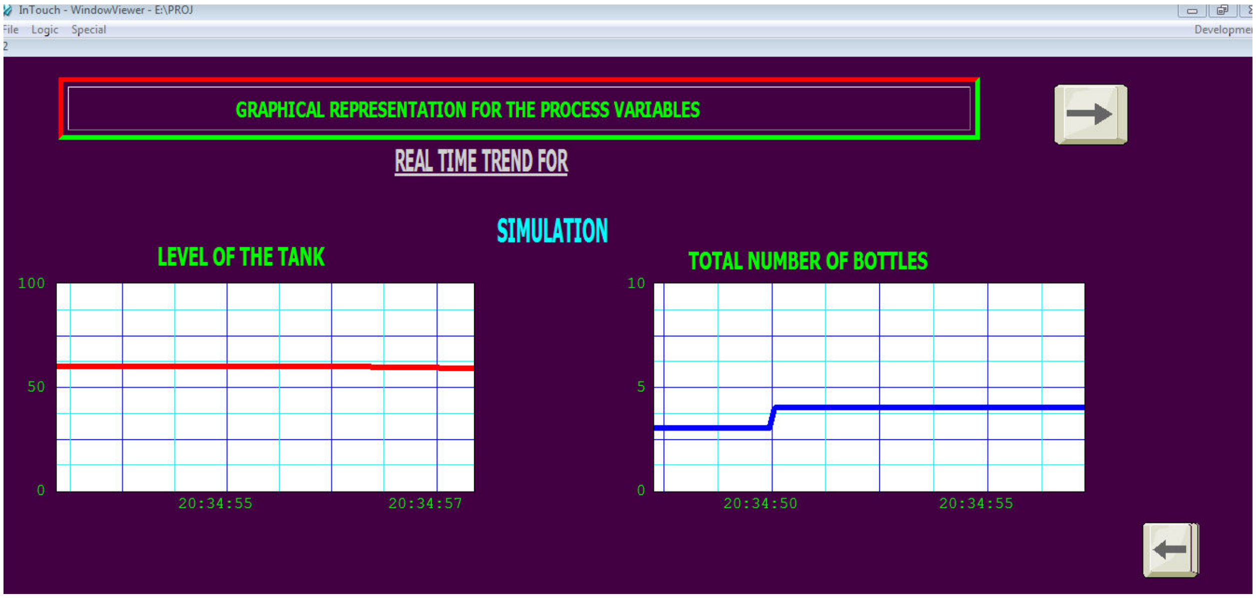


Figure 4.2 c graphic for tank and no. of bottle case 3

the next figure show graphical presentations for motor frequency and the change that been through the VSD control the motor frequency according to the speed that the motor need it to move the bottle in the conveyer belt as shown in figure 4.9 axel x for time ,y for frequency

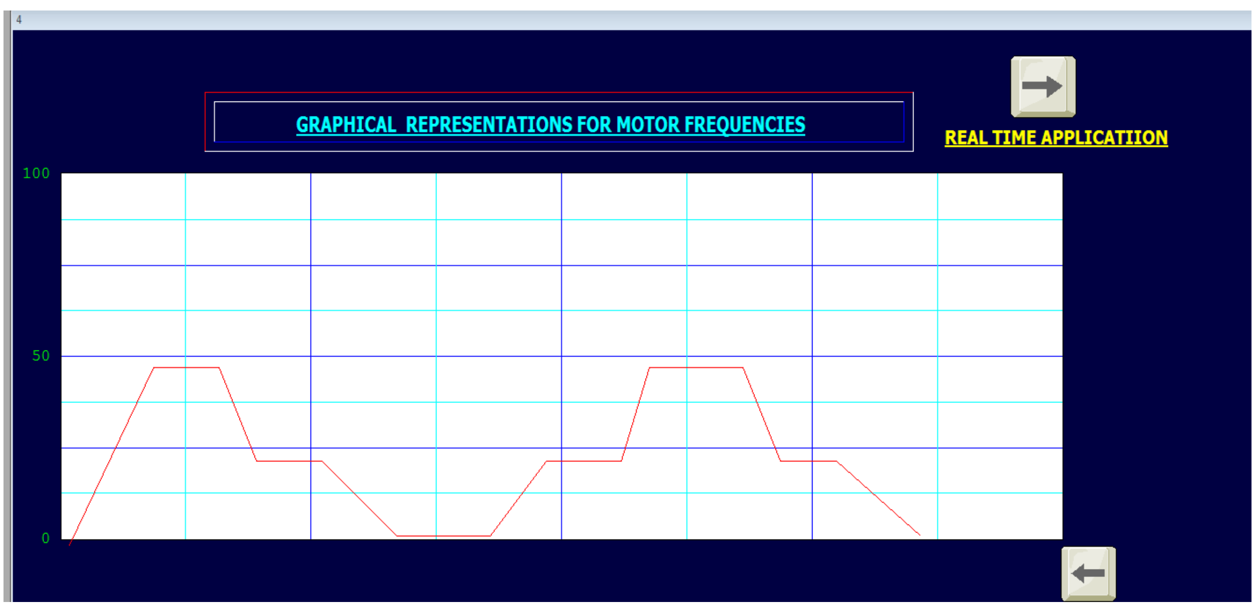


Figure 4. 3 graphic for motor speed

The figure below show the VSD unit for motor control in the real time application . This window provide full remote control to the VSD through the PLC and CSADA which can stop start the motor and change the frequencies to change the speed of the motor. Figure 4.10.a and 4.10. b show the different changes in the frequencies

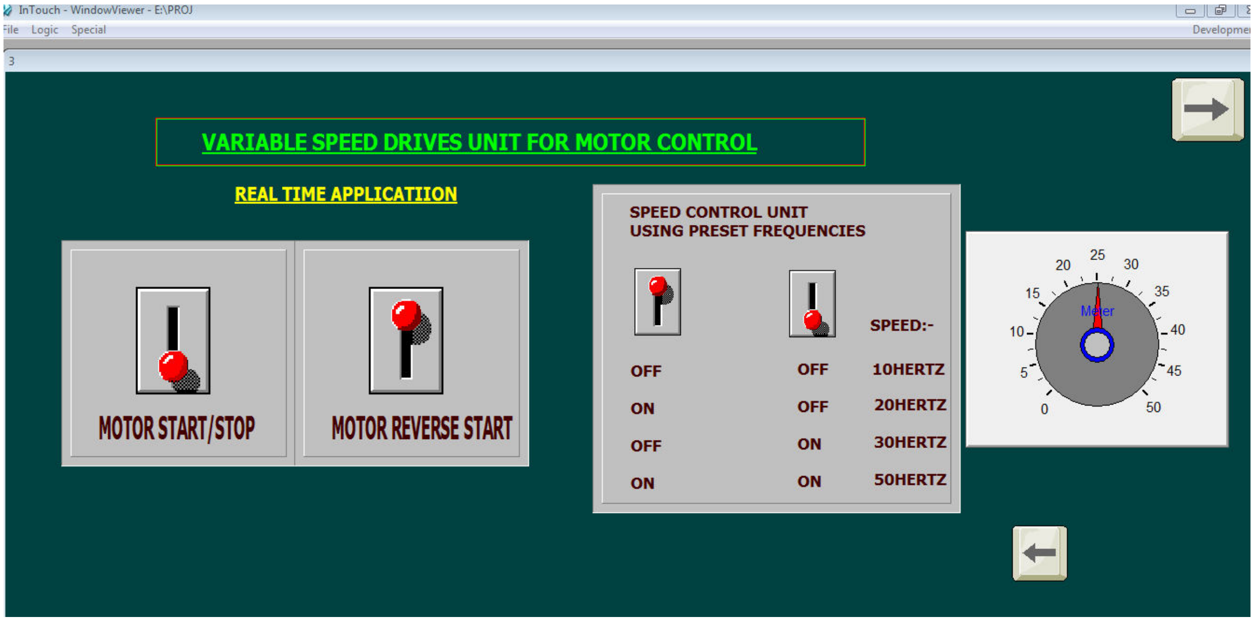


Figure 4.4. a VSD unit case1

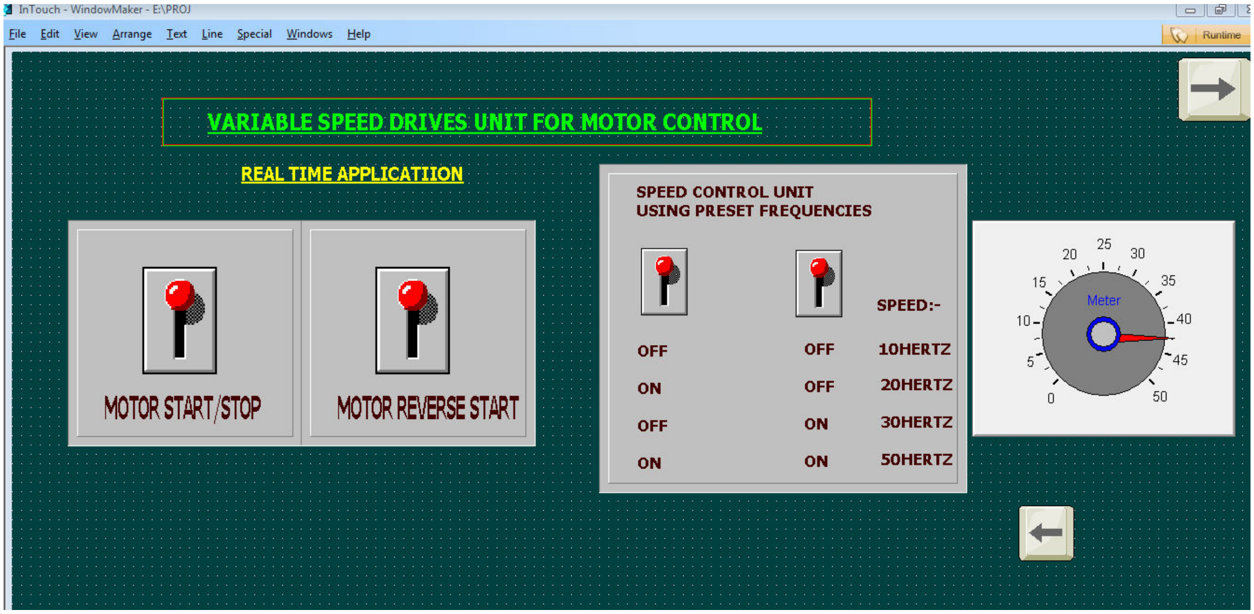


Figure 4.4. b VSD unit case2

Next figure show the window of safety and alarm in the real time application which contain indicators that monitor entire system. in the normal case all alarms light are green color and the alarm of the proximity change the color to red according to the position of the bottle in the conveyer belt. So For example if the motor over load the lamp will become red as shown in the Figure 4.11.a so then VSD well stop the motor

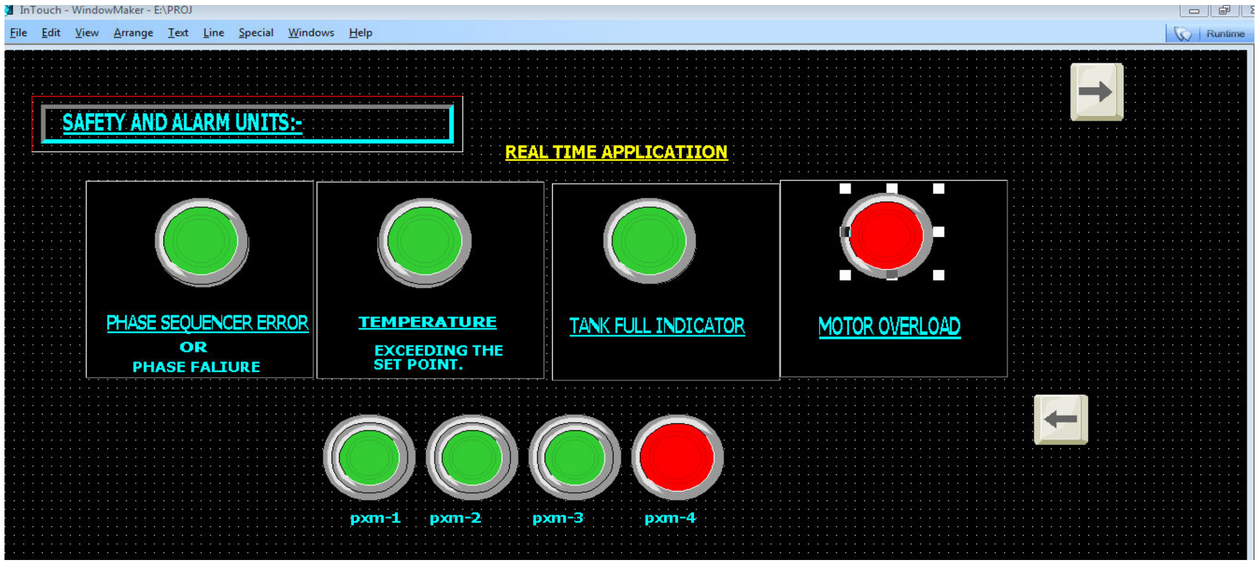


Figure 4.5. a safety and alarm unit

If the temperature sensor exceed the set point the alarm will become red as it show in figure 4.11.b then the heater well stop

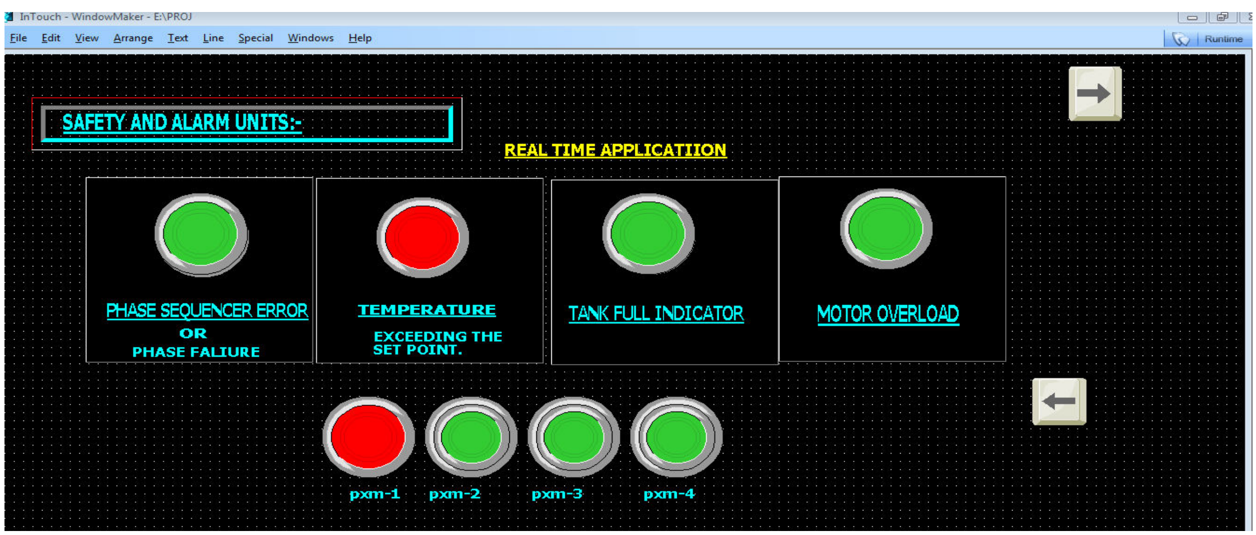


Figure 4.5. b safety and alarm unit

Also if the one of the phases of the power supply get lose or are not in the sequence the phase failure well send a signal and the alarm will become red as shown in figure 4.11.c so the VSD will stop the motor. All of this procedures are programmed in the PLC by Allen Bradley ladder language

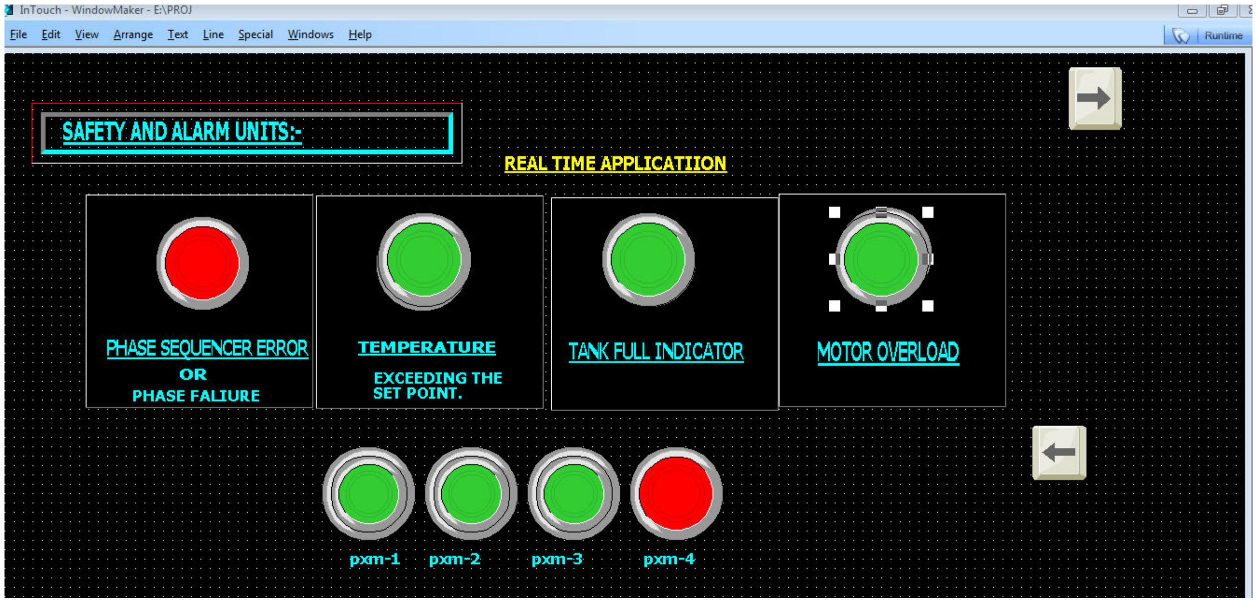


Figure4.5. c safety and alarm unit.

CHAPTER FIVE

RESULTS AND DISCUSSTION

CHAPTER FIVE

CONCULOTION AND RECOMENDATIONS

5.1 Conclusion

As a conclusion, the aim for control the motor speed by the VFD and automating process by PLC and through SCADA system has been achieved successfully. No human supervision was necessary. The PLC MicroLogix™ 1100 also offers many Input Output ports. Hence this single system can also take tank filling ,bottle filling and capping system which control the speed of the three phase induction motor of conveyer belt by VFD and automate the system by SCADA and PLC.

The main advantages of controlling speed of the three phase induction motor is saving energy and provide smooth starting and stopping.

Also using a smart phone application through network provide another advantage which can control and remote the entire process by phone instead of pc if it necessary.

5.2 Recommendations

this project still has many improvement that can be done such as

- add more sensors and protection devise that can provide more ratability, safety and accuracy.
- Implementation of the entire system .
- Controlling the speed of the induction motor can use in different applications

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20. GmbH, A. S. SEMENSE (2019)

APPENDEX

APPENDEX A

ladder program using RSLogix

This ladder program programmed by RSLogix program and linked to the PLC by RSLinx program . Rang 0 simulation the tank filling process as figure 4.1 blow the following

- Process start by main switch B3:00 15 which is activate the pump 1 B3:00 14 and valve 1 B3:00 10 to fill 50% of the tank and well stop when the liquid reach the set point of level sensor 2 B3:00 13.
- When level 2 is activate pump2 B3:00 11 and valve2 B3:00 9 well start to fill the left 50% to fill the tank when its full level sensor 1 well activate and cut off the signal from pump2 and valve 2.

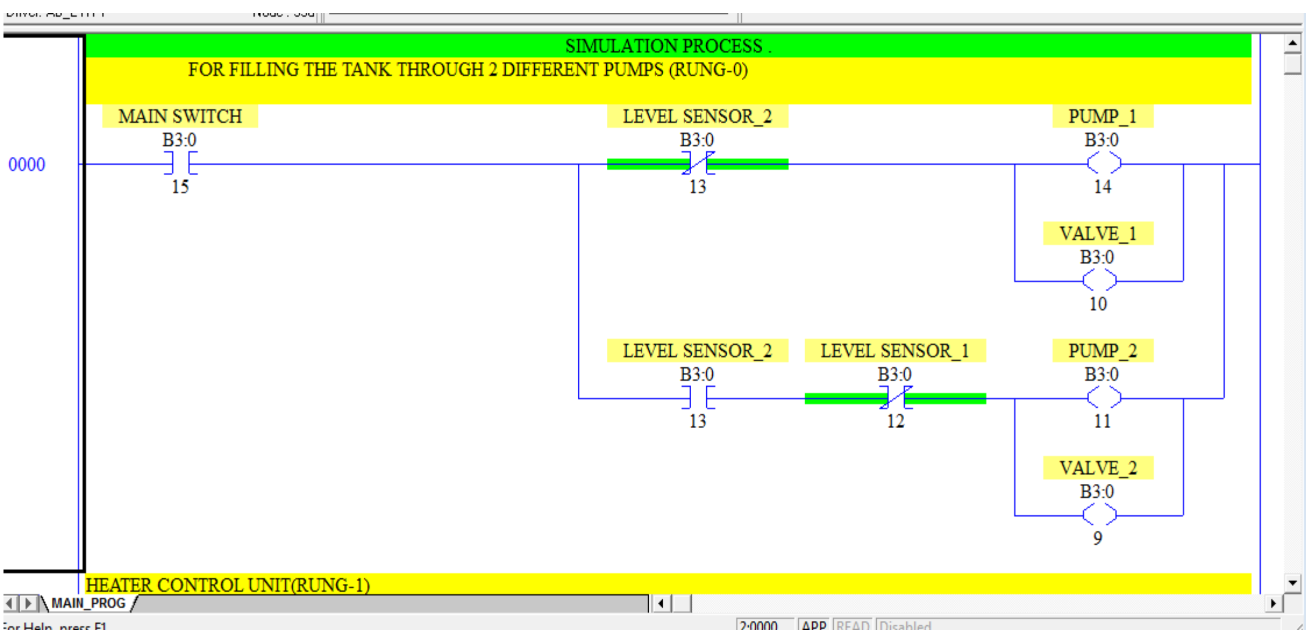
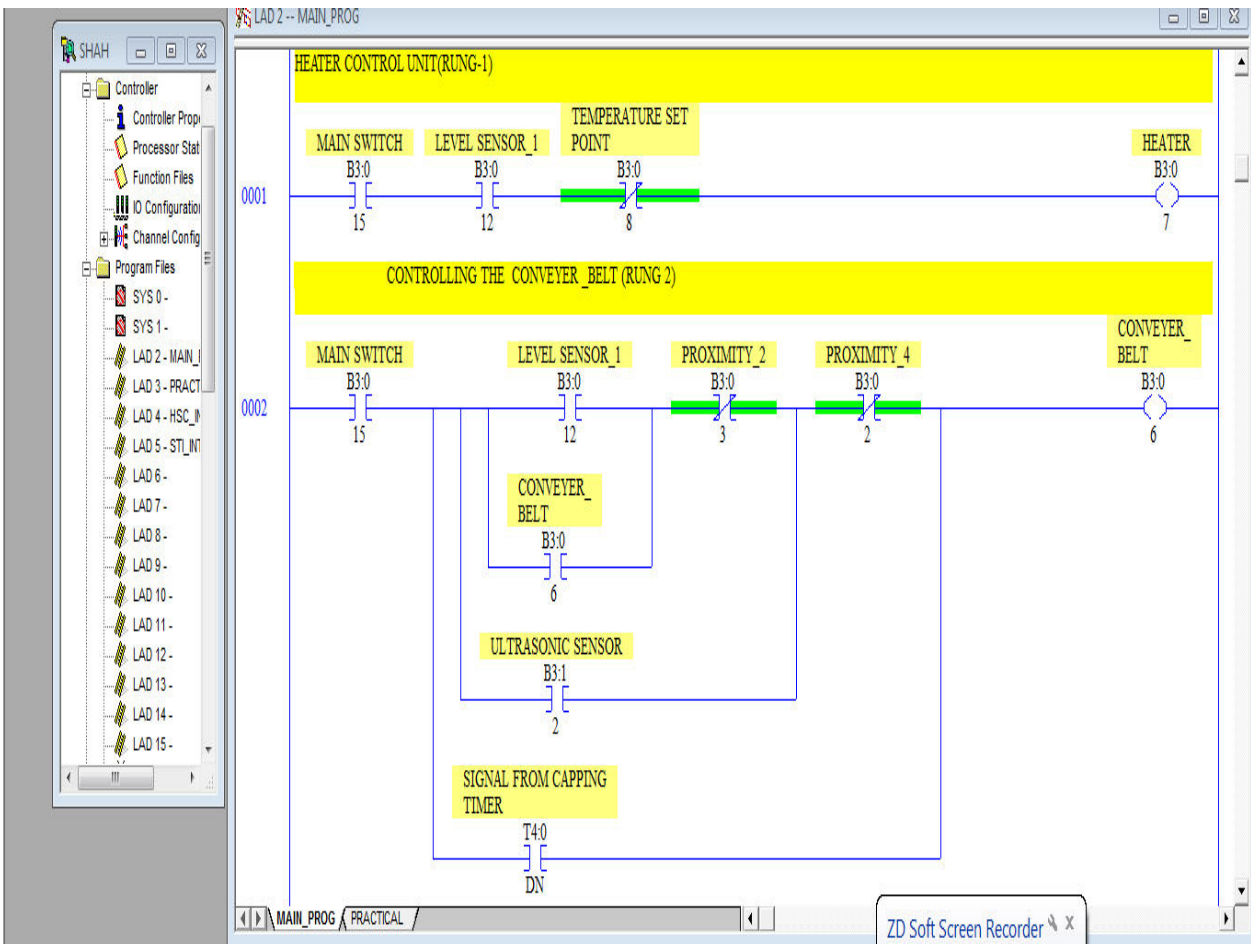


Figure 4.2 below is a simulation of heater control unit and conveyer belt controlling

- In rage 1 and when the level sensor1B3:00 12 is active the heater B3:00 7 will activate and heat up the liquid antel the temperatateure sensor B3:00 8 reach the set point then the heater will stop
- In the same time that heater is on the conveyor belt B3:00 6 motor signal well activate.
- Motor well stop if the proximity seneros 2 B3:00 3or proximity sensor 4 B3:00 5 are activate.
- The signal of the conveyer belt can activate if the timer of the capping machine T4:00 DN or photo sensor B3:00 signal is on.



the next figure show the simulation of controlling frequency using variable speed derive and capping system which is :

- When proximity sensor 1 B3:00 2 or proximity3 B3:00 4 are activate the speed frequency will slow down according to the signal change in VFD frequency 5 B3:00 4 for 5 second inthe delay timer T4:01DN, T4:02 DN
- When the signal of proximity sensor 4 B3:00 6 is activate the capping machine timerT4:00 TON well start timing for 5 second

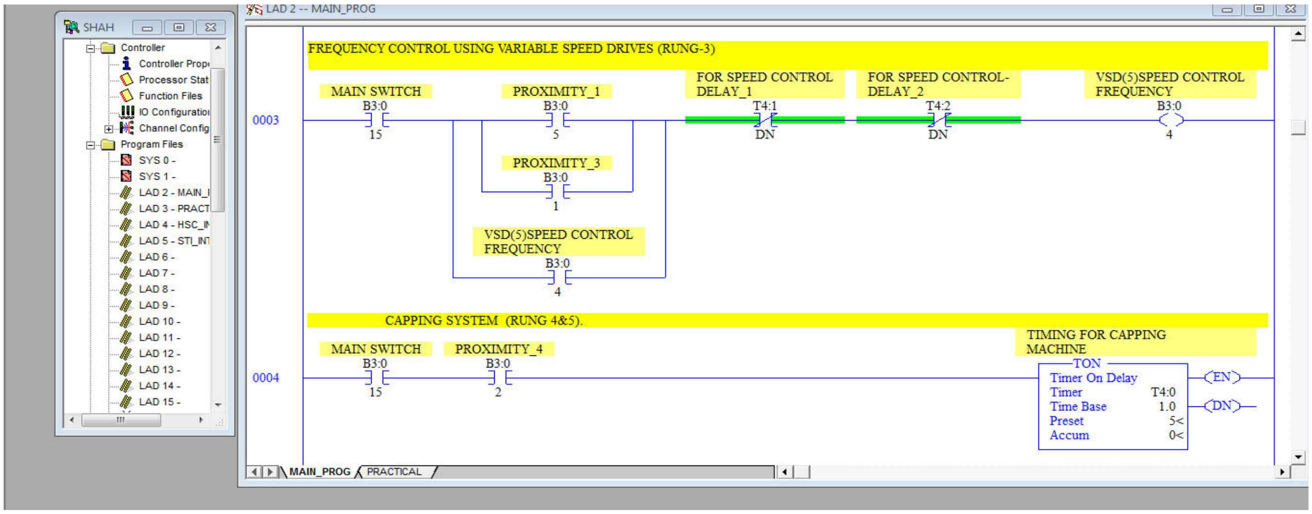


figure 4.4 providing extra delay for variable speed derive which is

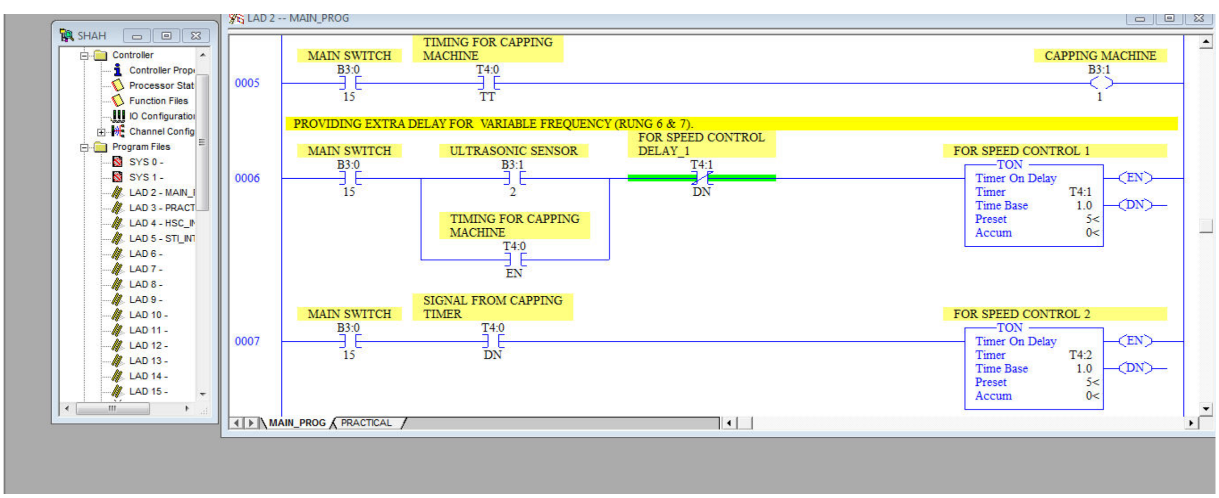
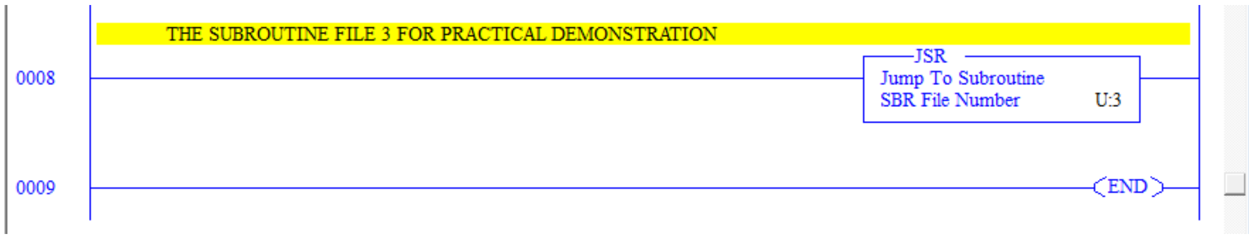
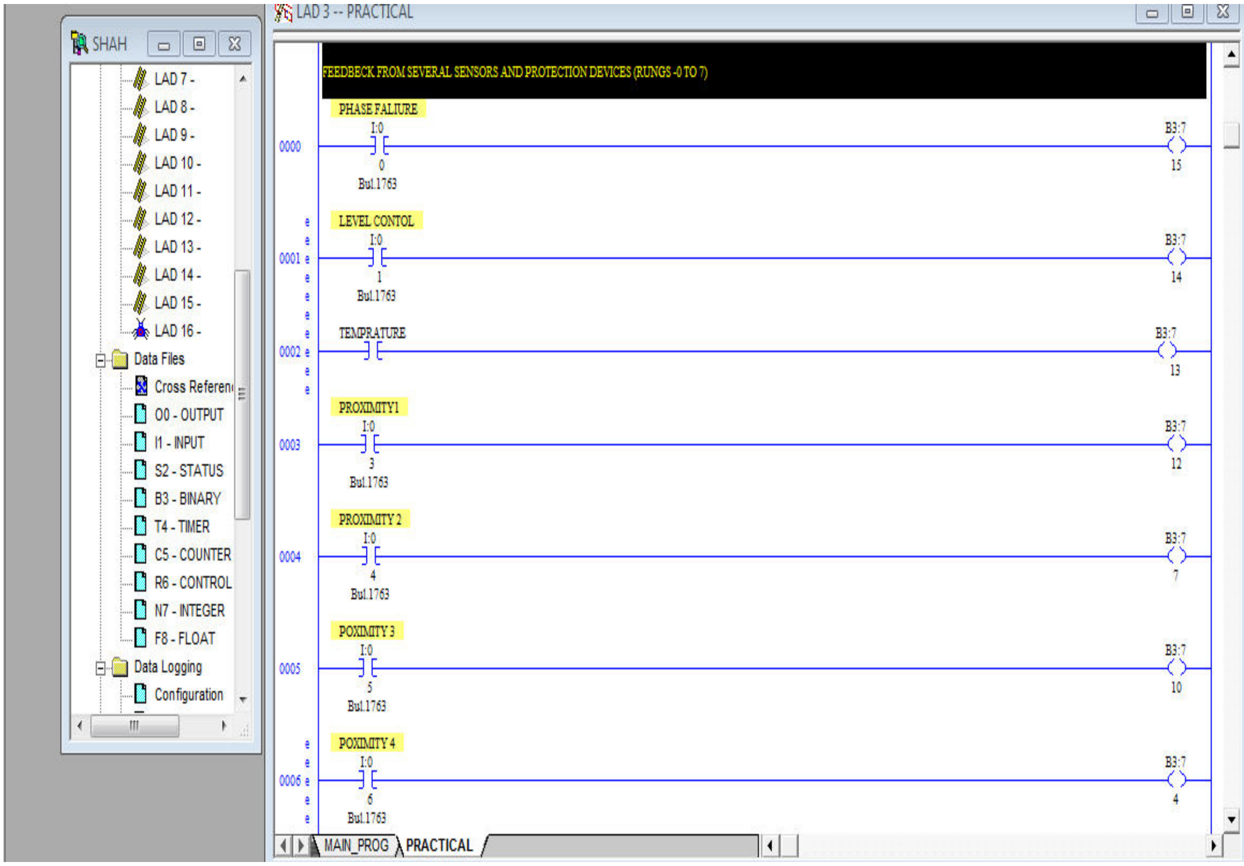
- the ultra photo sensor or the capping machine timer can activate the speed control1timerT4:01 TON and stop when the timer T4:1 DN is active
- \the capping machine time also can activate the speed control 2 timer T4:02 TON.
- 

Figure 4.5 is a sub routine file 3 for practical program



the practical program in the feedback from several sensors and protection device

Figure 4 .11 the practical program



SHAH
LAD 7 -
LAD 8 -
LAD 9 -
LAD 10 -
LAD 11 -
LAD 12 -
LAD 13 -
LAD 14 -
LAD 15 -
LAD 16 -
Data Files
O0 - OUTPUT
I1 - INPUT
S2 - STATUS
B3 - BINARY
T4 - TIMER
C5 - COUNTER
R6 - CONTROL
N7 - INTEGER
F8 - FLOAT
Data Logging
Configuration
LAD 3 -- PRACTICAL
FEEDBECK FROM SEVERAL SENSORS AND PROTECTION DEVICES (RUNGS -0 TO 7)
PHASE FALIURE
LEVEL CONTOL
TEMPRATURE
PROXIMITY1
PROXIMITY 2
POXIMITY 3
POXIMITY 4
MAIN_PROG
PRACTICAL

APPENDEX B

APPENEX B

VSD DATA SHEET

I/O Wiring Recommendations

Important points to remember about I/O wiring:

- Always use copper wire.
- Wire with an insulation rating of 600V or greater is recommended.
- Control and signal wires should be separated from power wires by at least 0.3 meters (1 foot).

Important: I/O terminals labeled "Common" <u>are</u> <u>not</u> referenced to the safety ground (PE) terminal and are designed to greatly reduce common mode interference.

ATTENTION: Driving the 4-20mA analog input from a voltage source could cause component damage. Verify proper configuration prior to applying input signals.

Control Wire Types

Table 1.G Recommended Control and Signal Wire(1)

Wire Type(s)	Description	Minimum Insulation Rating
Belden 8760/9460 (or equiv.)	0.8 mm^2 (18AWG), twisted pair, 100% shield with drain.	300V 60 degrees C (140 degrees F)
Belden 8770 (or equiv.)	0.8 mm^2 (18AWG), 3 conductor, shielded for remote pot only.	

(1) If the wires are short and contained within a cabinet which has no sensitive circuits, the use of shielded wire may not be necessary, but is always recommended.

I/O Terminal Block

Table 1.H I/O Terminal Block Specifications

Maximum Wire Size (1)	Minimum Wire Size (1)	Torque
1.3 mm^2 (16 AWG)	0.2 mm^2 (24 AWG)	0.5-0.8 N-m (4.4-7 lb.-in.)

(1) Maximum/minimum sizes that the terminal block will accept - these are not recommendations.

Maximum Control Wire Recommendations

Do not exceed control wiring length of 30 meters (100 feet). Control signal cable length is highly dependent on electrical environment and installation practices. To improve noise immunity, the I/O terminal block Common must be connected to ground terminal/protective earth. If using the RS485 (DSI) port, I/O Terminal 16 should also be connected to ground terminal/protective earth.

Figure 1.5 Control Wiring Block Diagram

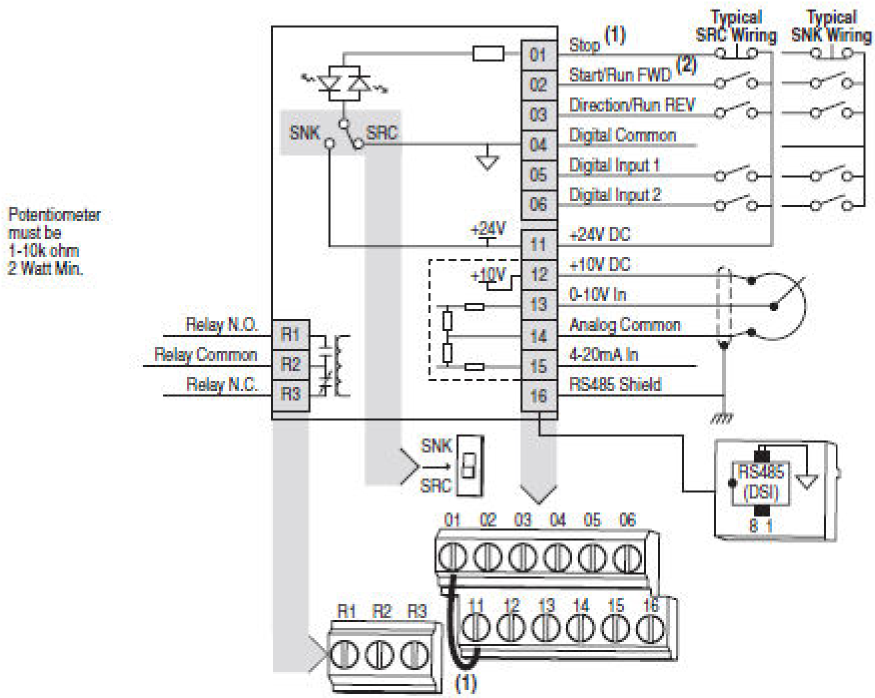
(1) **Important:** I/O Terminal 01 is always a coast to stop input except when P106 [Start Source] is set to "3-Wire" control. In three wire control, I/O Terminal 01 is controlled by P107 [Stop Mode]. All other stop sources are controlled by P107 [Stop Mode].

P106 [Start Source]	Stop	I/O Terminal 01 Stop
Keypad	Per P107	Coast
3-Wire	Per P107	Per P107
2-Wire	Per P107	Coast
RS485 Port	Per P107	Coast

Important: The drive is shipped with a jumper installed between I/O Terminals 01 and 11. Remove this jumper when using I/O Terminal 01 as a stop or enable input.

(2) Two wire control shown. For three wire control use a momentary input on I/O Terminal 02 to command a start. Use a maintained input for I/O Terminal 03 to change direction.

	30V DC	125V AC	240V AC
Resistive	3.0A	3.0A	3.0A
Inductive	0.5A	0.5A	0.5A

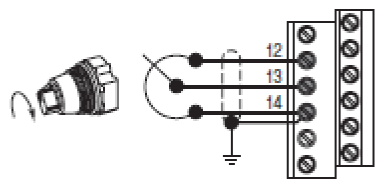
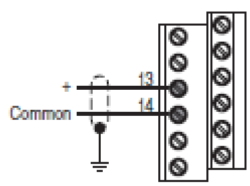
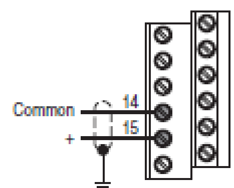
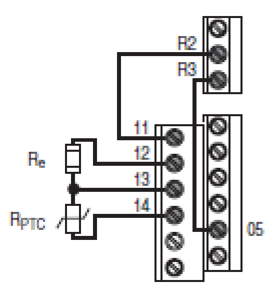


No.	Signal	Default	Description	Param.
R1	Relay N.O.	Fault	Normally open contact for output relay.	t221
R2	Relay Common	–	Common for output relay.	
R3	Relay N.C.	Fault	Normally closed contact for output relay.	t221
Sink/Source DIP Switch		Source (SRC)	Inputs can be wired as Sink (SNK) or Source (SRC) via DIP Switch setting.	
01	Stop (1)	Coast	The factory installed jumper or a normally closed input must be present for the drive to start.	P106 (1)
02	Start/Run FWD	Not Active	Command comes from the integral keypad by default. To disable reverse operation, see A095 [Reverse Disable].	P106, P107
03	Direction/Run REV	Not Active		P106, P107, A434
04	Digital Common	–	For digital inputs. Electronically isolated with digital inputs from analog I/O.	
05	Digital Input 1	Preset Freq	Program with t201 [Digital In1 Sel].	t201
06	Digital Input 2	Preset Freq	Program with t202 [Digital In2 Sel].	t202
11	+24V DC	–	Drive supplied power for digital inputs. Maximum output current is 100mA.	

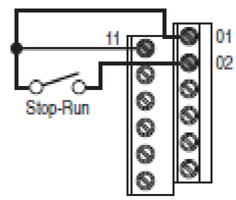
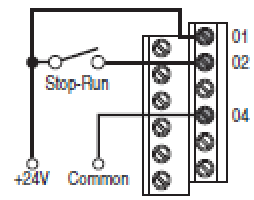
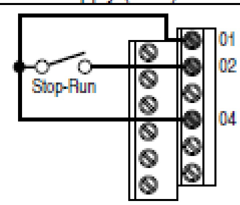
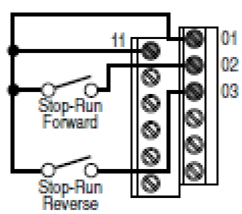
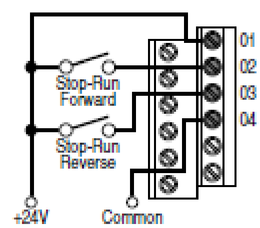
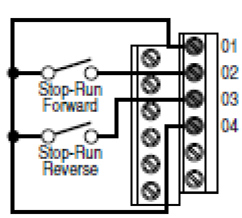
No.	Signal	Default	Description	Param.
12	+10V DC	–	Drive supplied power for 0-10V external potentiometer. Maximum output current is 15mA.	P108
13	0-10V In [3]	Not Active	For external 0-10V input supply (input impedance = 100k ohm) or potentiometer wiper.	P108
14	Analog Common	–	For 0-10V In or 4-20mA In. Electronically isolated with analog inputs from digital I/O.	
15	4-20mA In [3]	Not Active	For external 4-20mA input supply (input impedance = 250 ohm).	P108
16	RS485 (DSI) Shield	–	Terminal should be connected to safety ground - PE when using the RS485 (DSI) communications port.	

(3) Only one analog frequency source may be connected at a time. If more than one reference is connected at the same time, an undetermined frequency reference will result.

I/O Wiring Examples

<table>
<tr><th>Input</th><th colspan="2">Connection Example</th></tr>
<tr><td rowspan="2">Potentiometer
1-10k Ohm Pot. Recommended (2 Watt minimum)</td><td colspan="2">P108 [Speed Reference] = 2 “0-10V Input”</td></tr>
<tr><td colspan="2">
</td></tr>
<tr><td rowspan="2">Analog Input
0 to +10V, 100k ohm impedance
4-20 mA, 100 ohm impedance</td><td>Voltage
P108 [Speed Reference] = 2 “0-10V Input”</td><td>Current
P108 [Speed Reference] = 3 “4-20mA Input”</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td rowspan="2">Analog Input, PTC
For Drive Fault</td><td colspan="2">Wire the PTC and External Resistor (typically matched to the PTC Hot Resistance) to I/O Terminals 12, 13, 14.
Wire R2/R3 Relay Output (SRC) to I/O Terminals 5 & 11.
t201 [Digital In1 Sel] = 3 “Aux Fault”
t221 [Relay Out Sel] = 10 “Above Anlg V”
t222 [Relay Out Level] = % Voltage Trip</td></tr>
<tr><td colspan="2">

$$V_{Trip} = \frac{R_{PTC\ (hot)}}{R_{PTC\ (hot)} + R_e} \times 100$$</td></tr>
</table>

Input	Connection Example	
2 Wire SRC Control - Non-Reversing	Internal Supply (SRC)	External Supply (SRC)
P106 [Start Source] = 2, 3 or 4 Input must be active for the drive to run. When input is opened, the drive will stop as specified by P107 [Stop Mode]. If desired, a User Supplied 24V DC power source can be used. Refer to the "External Supply (SRC)" example.		 Each digital input draws 6 mA.
2 Wire SNK Control - Non-Reversing	Internal Supply (SNK)	
		
2 Wire SRC Control - Run FWD/Run REV	Internal Supply (SRC)	External Supply (SRC)
P106 [Start Source] = 2, 3 or 4 Input must be active for the drive to run. When input is opened, the drive will stop as specified by P107 [Stop Mode]. If both Run Forward and Run Reverse inputs are closed at the same time, an undetermined state could occur.		 Each digital input draws 6 mA.
2 Wire SNK Control - Run FWD/Run REV	Internal Supply (SNK)	
		

APPENDEX C

PLC DATA SHEET

I/O Configuration

This section discusses the various aspects of Input and Output features of the MicroLogix 1100 controllers. Each controller comes with a certain amount of embedded I/O, which is physically located on the controller. The controller also allows for adding expansion I/O.

This section discusses the following I/O functions:

- Embedded I/O on page 15
- MicroLogix 1100 Expansion I/O on page 17
- MicroLogix 1100 Expansion I/O Memory Mapping on page 17
- I/O Addressing on page 26
- I/O Forcing on page 27
- Input Filtering on page 27
- Latching Inputs on page 30

Embedded I/O

The MicroLogix 1100 provide discrete I/O and analog input that is built into the controller as listed in the following table. These I/O points are referred to as Embedded I/O.

Controller Family		Inputs		Outputs	
		Quantity	Type	Quantity	Type
MicroLogix 1100 Controllers	1763-L16BWA	10	24V dc discrete	6	relay
		2	0–10V dc analog		
	1763-L16AWA	10	120V ac	6	relay
		2	0–10V dc analog		
	1763-L16BBB	10	24V dc	2	relay
		2	0–10V dc analog	2	24V dc FET
				2	high-speed 24V dc FET
	1763-L16DWD	10	12/24Vdc	6	relay
		2	0–10V dc analog		

Analog I/O Configuration

The following table shows the data ranges for 0 to 10V dc and 4 to 20 mA.

Valid Input/Output Data Word Formats/Ranges

Normal Operating Range	Full Scale Range	Raw/Proportional Data	Scaled-for-PID
0 to 10V dc	10.5V dc	32,760	16,380
	0.0V dc	0	0
4 to 20 mA	21.0 mA	32,760	16,380
	20.0 mA	31,200	15,600
	4.0 mA	6240	3120
	0.0 mA	0	0

1762-IF2OF2 Input Data File

For each input module, slot x, words 0 and 1 contain the analog values of the inputs. The module can be configured to use either raw/proportional data or scaled-for-PID data. The input data file for each configuration is shown below.

Raw/Proportional Format

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	Channel 0 Data 0 to 32,768												0	0	0
1	0	Channel 1 Data 0 to 32,768												0	0	0
2	reserved															
3	reserved															
4	reserved														S1	S0
5	U0	O0	U1	O1	reserved											

Scaled-for-PID Format

Word	Bit Position															
	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
0	0	0	Channel 0 Data 0 to 16,383												0	0
1	0	0	Channel 1 Data 0 to 16,383												0	0
2	reserved															
3	reserved															
4	reserved														S1	S0
5	U0	O0	U1	O1	reserved											

The bits are defined as follows:

- Sx = General status bits for channels 0 and 1. This bit is set when an error (over- or under-range) exists for that channel, or there is a general module hardware error.

Controller Memory

File Structure

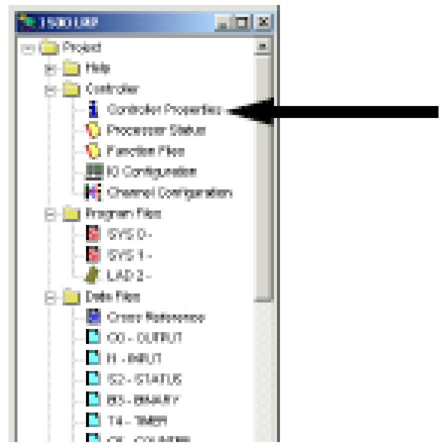
MicroLogix 1100 user memory is comprised of Data Files, Function Files, and Program Files.

TIP The file types shown below for data files 3 through 8 are the default file types for those file numbers and cannot be changed. Data files 9 through 255 can be added to your program to operate as bit, timer, counter, or other files shown below.

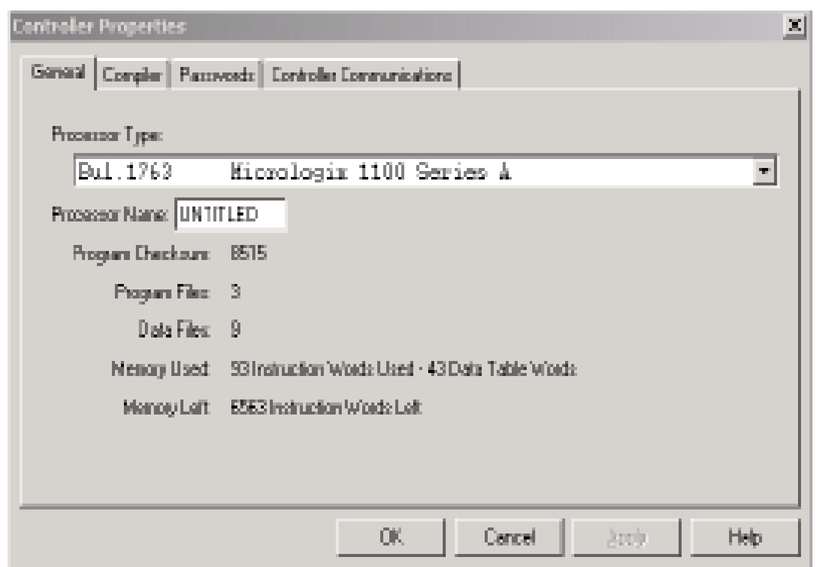
Data Files		Function Files		Program Files		Specialty Files	
0	Output File	HSC	High Speed Counter	0	System File 0	0	Data Log Queue 0
1	Input File	PTO	Pulse Train Output	1	System File 1	1	Data Log Queue 1
2	Status File	PWM	Pulse Width Modulation	2	Program File 2	2 to 255	Data Log Queues 2 to 255
3	Bit File	STI	Selectable Timed Interrupt	3 to 255	Program Files 3 to 255	0	Recipe File 0
4	Timer File	EII	Event Input Interrupt			1	Recipe File 1
5	Counter File	RTC	Real Time Clock			2 to 255	Recipe Files 2 to 255
6	Control File						
7	Integer File	MMI	Memory Module Information				
8	Floating Point File						
9 to 255	(B) Bit (T) Timer (C) Counter (R) Control (N) Integer (F) Floating Point (ST) String (L) Long Word (MG) Message (PD) PID (PLS) Programmable Limit Switch (RI) Routing Information (RIX) Extended Routing Information (OS Series B FRN 4 or later)	BHI	Base Hardware Information				
		CS	Communications Status				
		IOS	I/O Status				
		DLS	Data Log Status				
		LCD	LCD				
		ES	Ethernet Status				

Viewing Controller Memory Usage

1. Highlight and open *Controller Properties*.



2. The amount of *Memory Used* and *Memory Left* will appear in the *Controller Properties* window once the program has been verified.



Protecting Data Files During Download

Data File Download Protection

Once a user program is in the controller, there may be a need to update the ladder logic and download it to the controller without destroying user-configured variables in one or more data files in the controller. This situation can occur when an application needs to be updated, but the data that is relevant to the installation needs to remain intact.

This capability is referred to as *Data File Download Protection*. The protection feature operates when:

- A User Program is downloaded via programming software
- A User Program is downloaded from a Memory Module

Setting Download File Protection

Download File Protection can be applied to the following data file types:

- Output (O)
- Input (I)
- Binary (B)
- Timer (T)
- Counter (C)
- Control (R)
- Integer (N)
- Floating Point (F)
- String (ST)
- Long Word (L)
- Proportional Integral Derivative (PID)
- Message (MG)
- Programmable Limit Switch (PLS)
- Routing Information (RI)
- Extended Routing Information (RIX)

TIP	The data in the Status File cannot be protected.

Inputs and outputs addresses

Input N0	Input Adders	Output N0	Output Adders
I/0	Phase Failure	O/2	VFD Terminal 2
I/1	Level control	O/3	VFD Terminal 3
I/2	Temperature control	O/4	VFD Terminal 5
I/3	Proximity sensor1	O/5	VFD Terminal 6
I/4	Proximity sensor2		
I/5	Proximity sensor 3		
I/6	Proximity sensor4		