# Development of panel Plastic Pipe line operation

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Submitted to the College of Engineering

in partial fulfillment of the requirements for the degree of

Bachelor degree in Industrial Automation

Engineering

Palestine Polytechnic University

June 2015

## الخلاصة

# "تطوير لوحة تشغيل لخط إنتاج الأنابيب البلاستيكية"

تعتبر الأنابيب البلاستيكية من المنتجات الصناعية التي لا يمكن الاستغناء عنها، حيث يتم استهلاكها بشكل كبير، فهي تستخدم في كثير من مجالات الحياة، من أهمها: التمديدات الكهربائية ومشاريع الصرف الصحي....الخ، بالتالي أصبح هنالك الحاجة إلى أنتاج كميات هائلة من هذه الأنابيب.

لكن، يوجد مشاكل متعددة في خط إنتاج الأنابيب البلاستيكية: أولا صعوبة في عملية الصيانة وتتبع الخطأ، ثانيا كبر حجم لوحة التحكم وكثرة الأسلاك ، وأخيراً فقد للوقت والجهد الغير فعال. وفقا لذلك، لقد عملنا على تطوير التكنولوجيا الصناعية؛ لتحسين خط الإنتاج للتغلب على هذه المشاكل.

جاء هذا المشروع من خلال مؤسسة التكامل الصناعي ، حيث تم تطوير خط انتاج الأنابيب البلاستيكية المتواجد في شركة رويال، فقد استخدامنا مبرمجة PLC حتى تسهل عملية التوصيل مع خط الإنتاج وتتم عملية التحكم بالطريقة الالية، بالإضافة الى وجود عملية ربط للنظام باستخدام شاشة لمس تسمى Human machine interface(HMI).

## Abstract

### "Development of panel Plastic Pipe line operation"

Plastic pipe of industrial products that cannot be dispensed with where there is a large consumption of them, they are used in many areas of life, including: electrical projects and sanitation projects.... etc. So there became a need to produce huge quantities of these tubes.

However, there are multiple problems in the production line of plastic pipe: First, difficulty in maintenance process and error tracking. Secondly, the large size of the control panel and the large numbers of wires. Finally, the time and effort are not effective. We worked on the development of industrial technology to improve the automated production line; to overcome these problems.

Our project came by Industrial integration organization, where we developed the plastic pipe production line that exists in Royal Company. we used programing PLC in order to facilitate the connection processes with the pipe production line and this is a way to control on all system, in addition there will be a connect between the system and workers by using touch screen which is called (HMI).

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### 1.1: Literature Review

The main idea of this project is the development of control in the production line control from classic technology to modern technology .

### 1.2: Statement of the problem

There are different types of problems that can be faced with this project. The important problems are: the difficulty in tracking the errors in the system, As well as the presence of large amounts of wire on the production line and this leads to difficulty in the maintenance process as well, and that cannot be easily controlled. In addition there is difficulty when running the production line and calibration of parts Line. These things lead to the loss of time with no guarantee exit output as required.

### 1.3: Motivation

The motivations are shown in some points such as engaging in labor market by knowing how the production line is working and how use the pieces in the project, also can improvement our possibilities of maintenance and building automation programs.

### 1.4: Needed Technology

We need for high technology to be able to arrange the sequence of our system, so that we worked with high precision systems like PLC to communicate with the line using this program, the type of this technology is (Siemens PLC S200), and we used human machine interface (HMI), in addition to that we need to have some software programs such as Matlab program, and Cady Basic .

### 1.5: Project Description

This project is to improvement the plastic pipeline by using PLC program and HMI to make this work like modern technology, the controlling will include all of parts in the production line such as motors, vacuum pump, heaters, and pullers. Also we controlling the heat.

## 1.6: Time Table

Table (1.1): The timeline of the project.

| Tasks \ Weeks | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Literature Review and Problem Statement** | ■ | ■ | ■ | ■ | | | | | | | | | | | |
| **Proposing Methodology** | | | | | ■ | ■ | ■ | | | | | | | | |
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| **Typing The Report** | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | |
| **Report Submission** | | | | | | | | | | | | | | | ■ |

## 1.7: Expected Outcomes

With the completion of the work we will have a production line capable of running modern face of previous technology problems.

## Chapter two: Plastic material

## 2.1: Plastic material definition

Plastic is the general common term for a wide range of synthetic or semi-synthetic materials used in a huge, and growing, range of applications from packaging to buildings; from cars to medical devices, toys, clothes etc.

The term ''plastic'' is derived from the Greek word "plastikos" meaning fit for moulding, and "plastos" meaning moulded. It refers to the material's malleability or plasticity during manufacture that allows it to be cast, pressed, or extruded into a variety of shapes - such as films, fibers, plates, tubes, bottles, boxes, and much more.

There are two broad categories of plastic materials: thermoplastics and thermosetting plastics. Thermoplastics can be heated up to form products and then if these end products are re-heated, the plastic will soften and melt again. In contrast, thermoset plastics can be melted and formed, but once they take shape after they have solidified, they stay solid and, unlike thermoplastics cannot be remelted [1].

## 2.2: Type of plastic material

Everywhere you look you will find plastics. We use plastic products to help make our lives cleaner, easier, safer and more enjoyable. You will find plastics in the clothes we wear, the houses we live in, and the cars we travel in. The toys we play with, the televisions we watch, the computers we use and the CDs we listen to contain plastics. Even the toothbrush you use every day contains plastics!

Plastics are organic, the same as wood, paper or wool. The raw materials for plastics production are natural products such as cellulose, coal, natural gas, salt and, of course, crude oil. Plastics are today's and tomorrow's materials of choice because they make it possible to balance modern day needs with environmental concerns.

The plastics family is quite diverse, and includes: ABS/SAN, Epoxy resins, Expandable Polystyrene, Fluoropolymers, PET, Polycarbonate, Polyolefins, Polystyrene, PVC, PVdC, Styrenic polymers, and Unsaturated Polyester Resins (UPR).

All these types of plastics can be grouped into two main polymer families: Thermoplastics, which soften on heating and then harden again on cooling, and Thermosets which never soften when they have been moulded.

Examples of thermoplastics:

1) Acrylonitrile butadiene styrene – ABS
2) Polycarbonate - PC
3) Polyethylene – PE
4) Polyethylene terephthalate – PET
5) Poly(vinyl chloride) - PVC
6) Poly(methyl methacrylate) – PMMA

7) Polypropylene – PP
8) Polystyrene – PS
9) Expanded Polystyrene - EPS

Examples of Thermosets:

1) Epoxide (EP)
2) Phenol-formaldehyde (PF)
3) Polyurethane (PUR)
4) Polytetrafluoroethylene – PTFE
5) Unsaturated polyester resins (UP)

A range of additives are used to enhance the natural properties of the different types of plastics - to soften them, color them, make them more process able or longer lasting. Today not only are there many different types of plastics, but products can be made rigid or flexible, opaque, transparent, or coloured; insulating and conducting; fire-resistant etc., through the use of additives.

## 2.3: PVC plastic material

PVC (Polyvinyl-chloride) is one of the earliest plastics, and is also one of the most extensively used. It is derived from salt (57%) and oil or gas (43%). PVC is made from chlorine – produced when salt water is decomposed by electrolysis – with ethylene, which is obtained from oil or gas via a 'cracking' process. After several steps, this leads to the production of another gas: vinyl chloride monomer (VCM). Then, in a further reaction known as polymerisation, molecules of VCM link to form a fine white powder (PVC). This powder is mixed with additives (stabilizers and/or plasticizers) to achieve the precise properties required for specific applications as show in figure (2.1). The resulting PVC granules (compounds) or ready-to-use powders (pre-mixes) are then converted into the final product. As see in figure (2.2).

Figure (2.1): A variety of PVC material.

Figure (2.2): Plastic pipe made from PVC material.

**The benefits of PVC**

PVC's combination of properties enables it to deliver performance advantages that are hard to match. This material is durable and light, strong, fire resistant, with excellent insulating properties and low permeability. By varying the use of additives in the manufacturing of PVC products, features such as strength, rigidity, color and transparency can be adjusted to meet most applications, including:

1) Building products, including window frames and other profiles, floor and wall coverings, roofing sheets, linings for tunnels, swimming-pools and reservoirs.
2) Piping, including water and sewerage pipes and fittings, and ducts for power and telecommunications.
3) Coatings, including tarpaulins, rainwear and corrugated metal sheets.
4) Insulation and sheathing for low voltage power supplies, telecommunications, appliances, and automotive applications.
5) Packaging, pharmaceuticals, food and confectionery, water and fruit juices, labels, presentation trays.
6) Automotive applications, including cables, underbody coating and interior trimmings.
7) Medical products, including blood bags, transfusion tubes and surgical gloves.
8) Leisure products, including garden hoses, footwear, inflatable pools, tents.

## 2.4: Plastic behavior in extruder

Although there is no difference from the injection molding until a material is supplied, when the material is heated plastic in the heating cylinder, the position of screw is fixed, in general. Therefore, a resin which is made plastic is discharged continuously from the die. The discharged resin is molded into the basic shape and finally formed with the sizing die and cooled and solidified. The receiving equipment serves an auxiliary function to receive extruded products.

The products are cut or wound up according to their characteristics and purpose of use. This molding method is most suitable for molding pipes, sheets, and films with uniform cross sections. Figures (2.3) and (2.4) explain that.

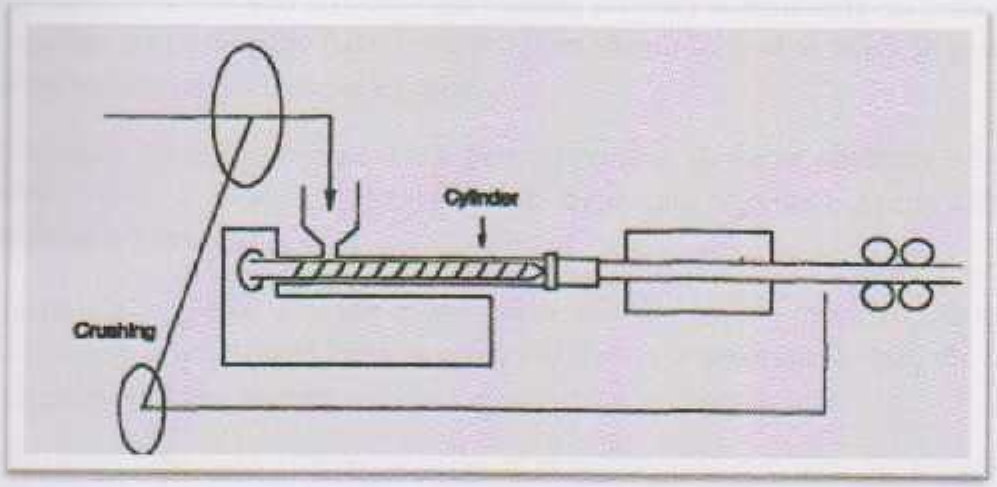



Figure (2.3): Extrusion molding process.

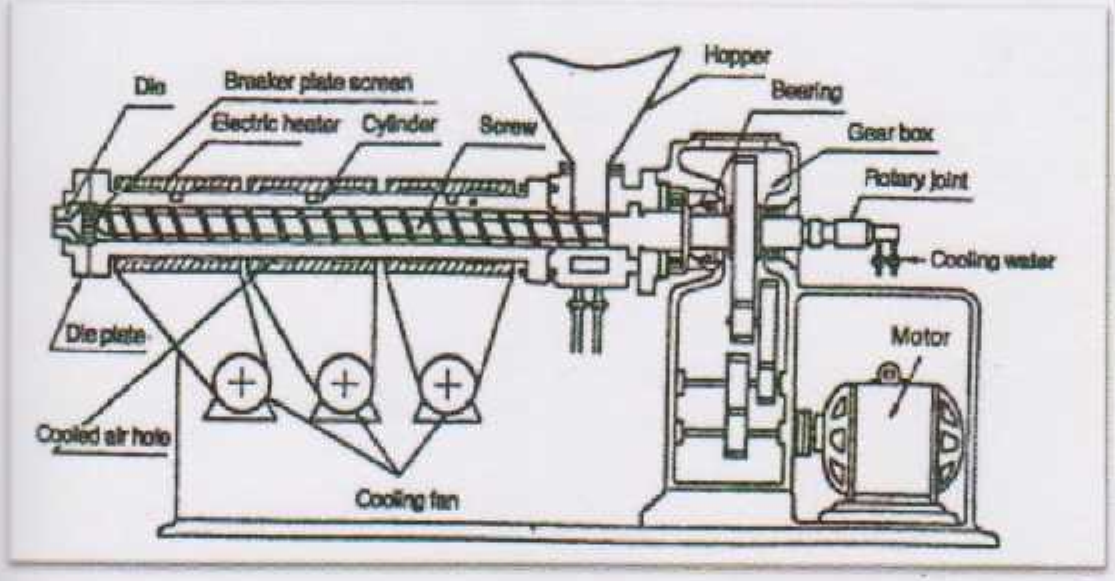



Figure (2.4): Mono-axis extruder.

**Raw material process and Quality control of materials.**

The forming materials have unexpectedly large non-uniformity of quality. Although the non-uniformity of quality of general purpose materials which are supplied continuously may not be very conspicuous, it should be assumed that this non uniformity of engineering plastics is very large in batch production. Therefore, control of products and material lots should always be made.

Although the non-uniformity of quality may not be a serious problem for injection molding, it is an important factor for extrusion molding.

The sizes of pellets also influence the forming property significantly. In particular, when pellets are used in the flake form, attention should be paid as much as possible to the uniformity of size and mixing ratio.

Coloring is generally conducted in a separate process. However, when the coloring quantity is large, coloring may be carried out by mixing coloring pigment with the screw (hopper blending).

Quantity of coloring with the master batch may not require much attention, but when a dry color or a liquid color is used, and then it is necessary to take the color change procedure into account.

If pellets in the form of flake or pellet of extremely different sizes are transferred with the hopper loader or the dryer by combined use of the hopper loader, there is a possibility of causing separation of pellets resulting in defective molding [2].

## Chapter three: Components of the system

## 3.1: Power circuit

Power circuit is the main part in any production line, that are considered effective portion which can be seen at work. Also it is consists of huge machines; such as heaters, washing machines.....etc. In addition, the current flowing in this circuit is very high compared to the control circuit.

### 3.1.1: Induction motor

The reason for the name "Squirrel cage" is because of the type of rotor used in these motors. Almost 95% of the induction motors used is of squirrel cage type, figure (3.1).

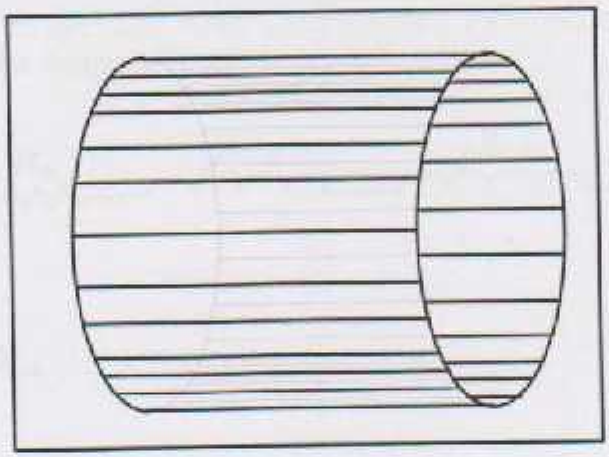


Figure (3.1): Squirrel cage rotor construction

The three-phase squirrel cage induction motor is the most widely used motor type in the industry because of its good self-starting capability, simple and rugged structure, low cost and reliability [3].

The principle of operation of the induction motor is based on generating a rotating constant magnetic field. Within a 3 phase motor, this is achieved by orientating the three coils 120 physical degrees apart in space, and imposing 3 phase voltages on the windings also separated in time by 120 electrical degrees. This results in a constant amplitude magnetic flux rotating at the frequency of the supply for a two pole motor.

The rotor will run at a speed slightly less than the synchronous speed. The rotating magnetic field is rotating at the synchronous speed. This leads to a relative speed between the magnetic field and the rotor, which is termed the slip, so the synchronous speed of an induction motor is [4]:

$$n_{synch} = \frac{120 \times f}{P} \qquad (2.1)$$

Where the synchronous speed is the speed at which the magnetic field is rotating. Also the difference in speed between the synchronous speed and the actual rotor speed, is referred to as the slip (s), the slip is:

$$s = \frac{n_{synch} - n}{n_{synch}} \quad (2.2)$$

The frequency of the currents and voltages in the rotor is scaled down by the value of the slip. If the motor is at standstill, the frequency in the rotor is equal to the frequency in the stator; if the motor is running exactly at synchronous speed, the frequency is zero. In general, the frequency of voltage and current in the rotor is:

$$f_r = s \times \mathrm{f} \quad (2.3)$$

Now, the model of an induction motor (with the rotor components reflected onto the stator) is shown in the figure (3.2).

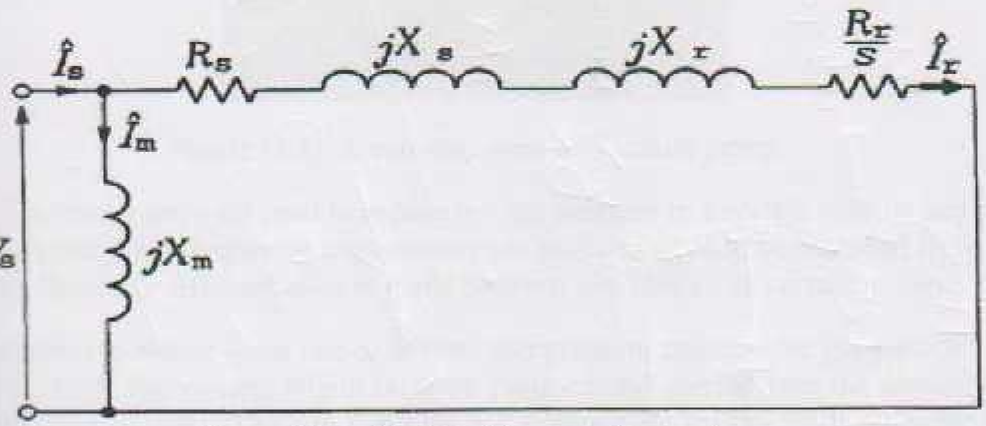



Figure (3.2): Model of the induction motor.

And after make the suitable analysis to Derivation of speed torque equation for an induction motor, you get on the following equation (4):

$$\tau(s) = \frac{3 \cdot V_s^2 \cdot \frac{R_r}{S}}{\left(R_s + \frac{R_r}{S}\right)^2 + (X_s + X_r)^2} \quad (2.4)$$

### 3.1.2: Vacuum motor

A vacuum pump as shown in figure (3.3) is a device that removes gas molecules from a sealed volume in order to leave behind a partial vacuum.

Figure (3.3): A cutaway view of Vacuum pump.

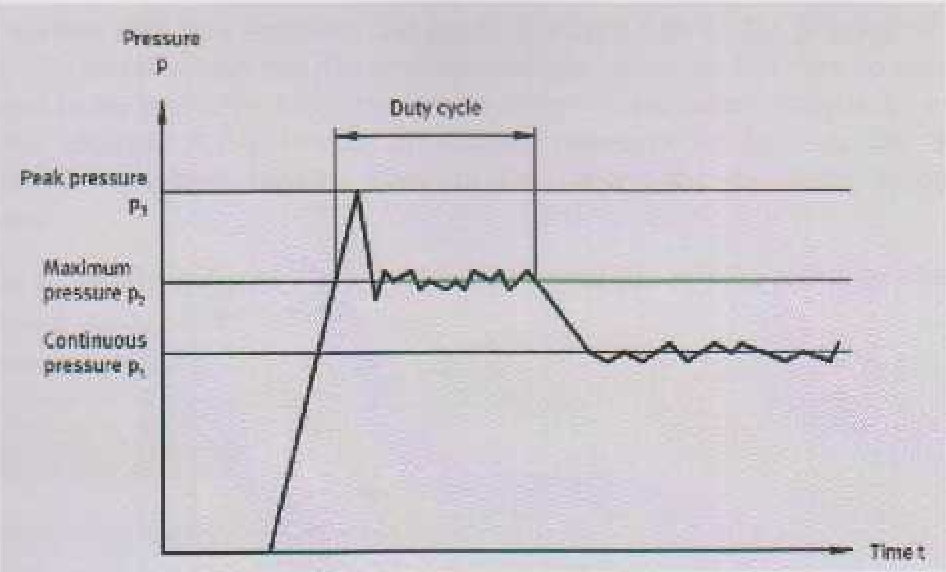
Vacuum pumps are used to reduce the gas pressure in a certain volume and thus the gas density. Consequently consider the gas particles need to be removed from the volume. Basically differentiation is made between two classes of vacuum pumps:

Vacuum pumps where – via one or several compression stages – the gas particles are removed from the volume which is to be pumped and ejected into the atmosphere (compression pumps). The gas particles are pumped by means of displacement or pulse transfer. Also Vacuum pumps where the gas particles which are to be removed condense on or are bonded by other means (e.g. chemically) to a solid surface, which often is part of the boundary forming volume itself [5].

### 3.1.3: Pump

Centrifugal pumps are best suited for large volume applications or for smaller volumes when the ratio of volume to pressure is high. The selection of the proper pump will depend on the system throughput, viscosity, specific gravity, and head requirements for a particular application. Where a variety of products with different characteristics are handled, it may be necessary to utilize multiple pumps either in series or parallel, or a series–parallel combination, or pumps with variable speed capabilities to achieve the desired throughput at least cost.

The operating pressure is of significant for the area of application of pumps. Peak pressure is specified. However, this should arise only briefly see figure (3.4) as otherwise the pump will wear out prematurely.




Figure(3.4):operation pressure.

## 3.1.4: Heater

Band heaters: of all types are used to heat cylinders. they are used on the plastic extruder, it consist from an electrical resistance ribbon, which are present between two sheets of mica, it are the combination of the materials dielectric strength which are present between resistance ribbon and outer surface, of the component either mild steel or stainless steel.

The expected maximum operating temperature of the heater is the major consideration in choosing the resistance alloy, the mica type, and the sheet metal alloy. For optimum heater performance and lifetime, the Must be the surface heated cylinder on smooth and without bumps and the inside diameter must be suitable, there must be a contact between heat surfaces and extruder surfaces, for good heat transfer.

There are just three basic causes of shortened life: The conductive material makes a path between the resistance and outer surface or between the resistance laps, thus causing an electrical short. Contaminants are water, oil, and plastic. Also over-temperature is exceeding the design maximum temperature of any heater.

## 3.1.5: Heat exchanger

A heat exchanger is a device that is used for transfer of thermal energy (enthalpy) between two or more fluids, between a solid surface and a fluid, or between solid particulates and a fluid, at differing temperatures and in thermal contact, usually without external heat and work interactions [6].

The heat transfer surface is a surface of the exchanger core that is in direct contact with fluids and through which heat is transferred by conduction. The portion of the surface that also separates the fluids is referred to as the primary or direct surface. To increase heat transfer area, appendages known as fins may be intimately connected to the primary surface to provide extended, secondary, or indirect surface. Thus, the addition of fins reduces the thermal resistance on that side and thereby increases the net heat transfer from/ to the surface for the same temperature difference.

And as shown in figure (3.5), you can see principle of heat exchanger between heating and cooling operations [7].

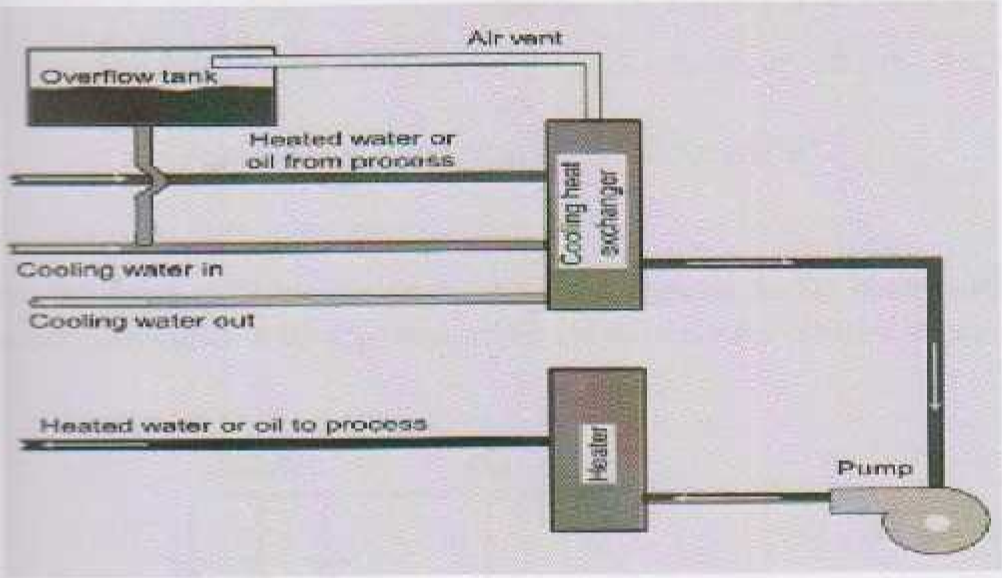



Figure (3.5): principle of heat exchanger.

## 3.1.6: Frequency converters.

Frequency converters are used to change the frequency and magnitude of the constant grid voltage to a variable load voltage. Frequency converters are especially used in variable frequency AC motor drives.

Working Principle of Frequency Converters:

1) Convert from AC to DC "Converter": Through used six diodes we can convert AC voltage to DC voltage, they allow current to flow in only one direction.

As shown in figure (3.6); when A-phase voltage is more positive than B or C phase voltages, then that diode will open and allow current to flow. When B-phase becomes more positive than A-phase, then the B-phase diode will open and the A-phase diode will close. The same is true for the three diodes on the negative side of the bus. Thus, we get six current "pulses" as each diode opens and closes.

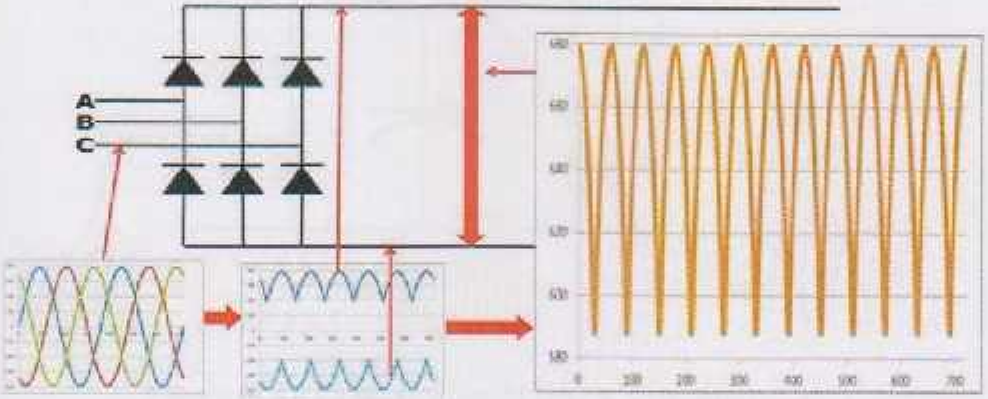



Figure (3.6): Convert from AC to DC "Converter".

2) DC Bus figure (3.7): We can get rid of the AC ripple on the DC bus by adding a capacitor. This capacitor absorbs the ac ripple and delivers a smooth dc voltage.

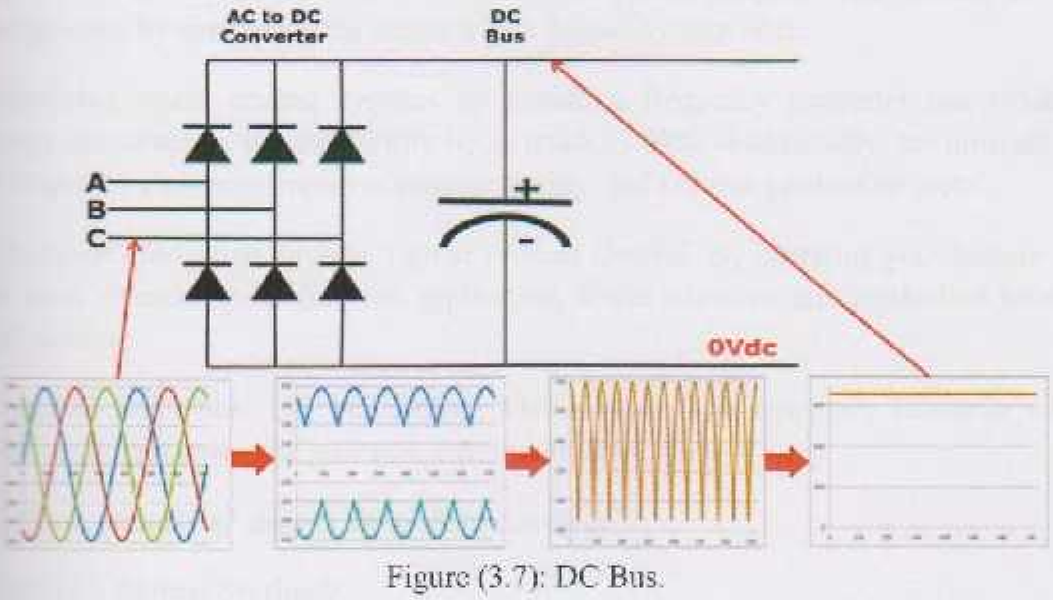



Figure (3.7): DC Bus.

3) Convert from DC to AC "Inverter": Through used six transistors we can convert DC voltage to AC voltage, they allow us to make any phase be positive, negative, or zero. It control by pulse width modulation as shown in figure (3.8).

When we close one of the top transistors in the inverter, that phase of the motor is connected to the positive dc bus and the voltage on that phase becomes positive. When we close one of the bottom transistors in the converter, that phase is connected to the negative dc bus and becomes negative. Thus, we can make any phase on the motor become positive or negative at will and can thus generate any frequency.

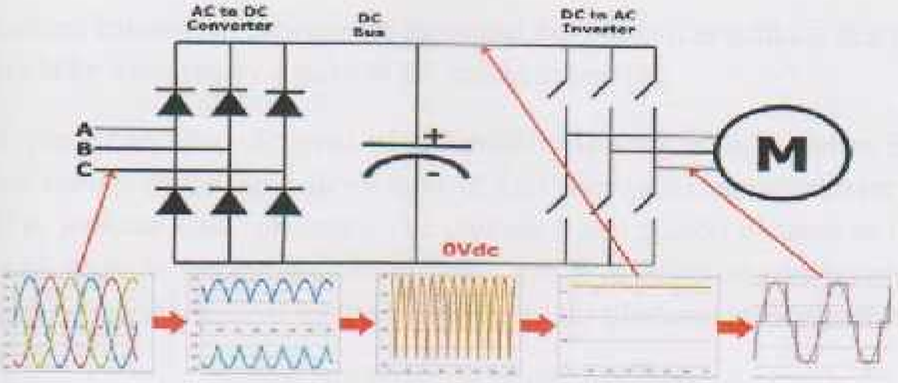



Figure (3.8): Convert from AC to DC "Inverter".

Frequency Converter is an important part in any electrical drive system, so it can do without it never and it have many benefits, including:

1. Reduce Energy Consumption and Energy Costs: Electric motor systems are responsible for more than 65% of the power consumption in industry today, any application that does not need to be run at full speed, and then you can cut down energy costs by controlling the motor with a frequency converter.

Optimizing motor control systems by installing frequency converter can reduce energy consumption in your facility by as much as 60%. Additionally, the utilization of frequency converter improves product quality, and reduces production costs.

2. Increase Production through Tighter Process Control: By operating your motors at the most efficient speed for your application, fewer mistakes, and production levels will increase.

3. Extend Equipment Life and Reduce Maintenance: The frequency converter will offer better protection for your motor from issues such as:

A) Phase protection" under voltage & overvoltage".

B) Electro thermal overloads.

C) Phase failure.

### 3.1.7: Solid state relay

Solid state relays serve the same function as mechanical relays but have no moving parts (hence the name solid state). They are semiconductor devices that either block or allow the load current to flow depending on the input to the relay. The inputs on most SSR's are isolated from the load. This means the circuit that triggers the relay doesn't have to be referenced to the same ground as the load (i.e. isolated). Since there is no electrical connection between the input and the output it is unlikely that the input circuit could be damaged by a spike in the output circuit [8].

A simplified block diagram of an optically isolated SSR is shown in figure (3.9). Any voltage on the input above three or four volts sends enough current through the LED to generate light (photons). The photons travel a short distance in the relay and hit a photodiode, phototransistor, or other optical to electrical conversion device. The output switch is triggered by the current from the photodiode, phototransistor, or whatever.

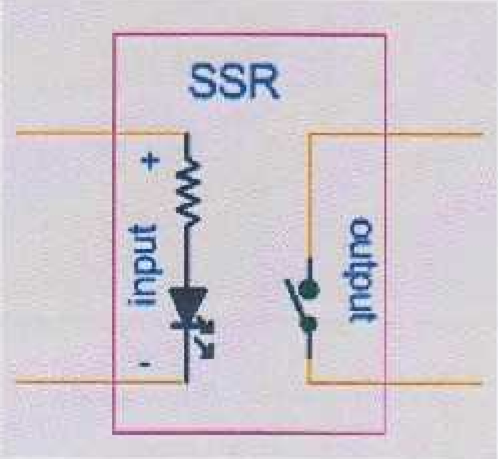



Figure (3.9): A simplified block diagram of an optically isolated.

### 3.2: Control circuit

Control circuit is considered a vital part in any industrial system, and without the control circuit the system will not be effective, as well as production machines will remain fixed, so it is impossible neglect the control circuit.

Moreover, the flowing current through control circuit very small compared with the power circuit, as previously shown. In addition to that, there are two types of control circuits: the traditional control and automatic control. In our project we will use automatic control.

## 3.2.1: PLC

Programmable Logic Controllers (PLCs), also referred to as programmable controllers, are in the computer family. They are used in commercial and industrial applications. A PLC monitors inputs, makes decisions based on its program, and controls outputs to automate a process or machine.

The S7-200 (shown in figure 3.10) is referred to as a micro PLC because of its small size. The S7-200 has a brick design which means that the power supply and I/O are on-board. The S7-200 can be used on smaller, stand-alone applications such as elevators, car washes or mixing machines. It can also be used on more complex industrial applications such as bottling and packaging machines. And in our project we will use this type of PLC.

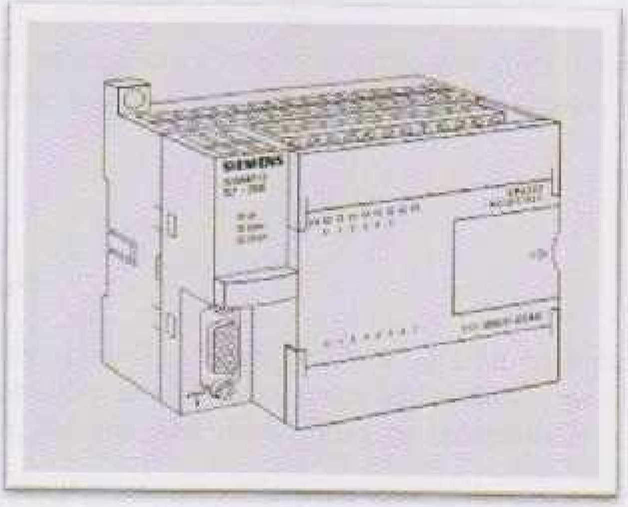


Figure (3.10): The S7-200 PLC.

The S7-200 PLCs are expandable. Expansion modules contain additional inputs and outputs as shown in figure (3.11). These are connected to the base unit using a ribbon connector.

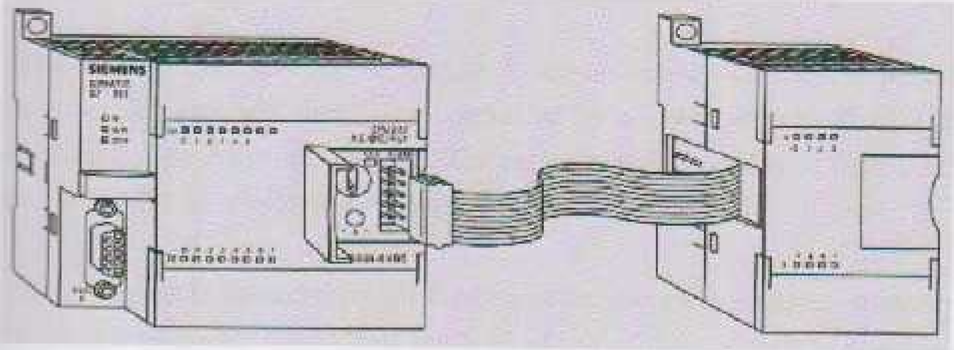


Figure (3.11): CPU with an Expansion Module.

PLCs must also work with continuous or analog signals. Typical analog signals are 0 - 10 VDC or 0 - 20 mA. Analog signals are, used to represent changing values such as speed, temperature weight, and level. A PLC cannot process these signals in an analog form. The PLC must convert the analog signal into a digital representation. An expansion module, capable of converting the analog signal, must be used.

The S7-200 analog modules convert standard voltage and current analog values into a 12-bit digital representation. The digital values are transferred to the PLC for use in register or word locations [9].

In addition, analog modules are available for use with thermocouple and RTD type sensors used in to achieve a high level of accuracy in temperature measurement.

### *3.2.2: HMI*

An HMI, or Human-Machine Interface, is a device or software that lets users communicate with a machine or automation system. Besides translating complex data into useable information, an HMI relays the user's commands.

By providing information, alerts, commands and other tools, an HMI connects the user with the process being controlled. So the more adapted the tools are to the user.

### 3.2.3: Contactor

Contactors (as shown in figure 3.12) are useful in industrial applications, particularly for controlling large lighting loads and motors. One of their hallmarks is reliability. However, like any other device, they are not infallible.

As contactors are used for high-current load applications they are designed to control and reduce the arc produced when the heavy motor currents are interrupted.

Other than the low current contacts, they are also setup with Normally Open contacts. These are devices which handle more than 20 Amperes current and over 200 Kilo Watt's power.

The contactor has an AC/DC supply driven coil input. This will depend on the requirement. This coil will mostly be controlled by a lower voltage PLC. They can also be controlled by the motor voltage. The motor may have series of coils connected to either control the acceleration or even the resistance.

When current is passed through the contactor, the electromagnet starts to build up, producing a magnetic field. Thus the core of the contactor starts to wind up. This process helps in energizing the moving contact. Thus the moving and fixed contacts make a short circuit. Thus the current is passed through them to the next circuit. The armature coil brings in high current in the initial position. This reduces as soon as the metal core enters the coil. When the current is stopped, the coil gets de-energized and thus the contacts get open circuited [10].

Figure (3.12): contactor device.

### 3.2.4: Sensors

A sensor, (also referred to as a transducer) is an input device that provides a usable output in response to a physical input .For example, a thermocouple gives a voltage output that is directly related to the temperature it measures.

The following considers a typical range of sensors, which you may come across in distributed control system environments [11].

#### 3.2.4.1: Thermocouple sensor

In production control systems, temperature measurements are very common. Awareness of temperature is particularly important in situations where volatile chemicals or flammable materials (e.g. oil, gas) are involved.

Thermocouple is consists of two dissimilar connected conductors as shown in figure (2.13), which produce a voltage when heated. The voltage produced being a function of the difference in temperature between the connection point (hot junction) and other parts of the circuit (cold junction).

The thermocouple like any device maybe have Advantages; such as self-contained and cheap and it maybe have disadvantage such as; accuracies better than 1 °C are difficult to achieve. And in our project we will use thermocouple type J.

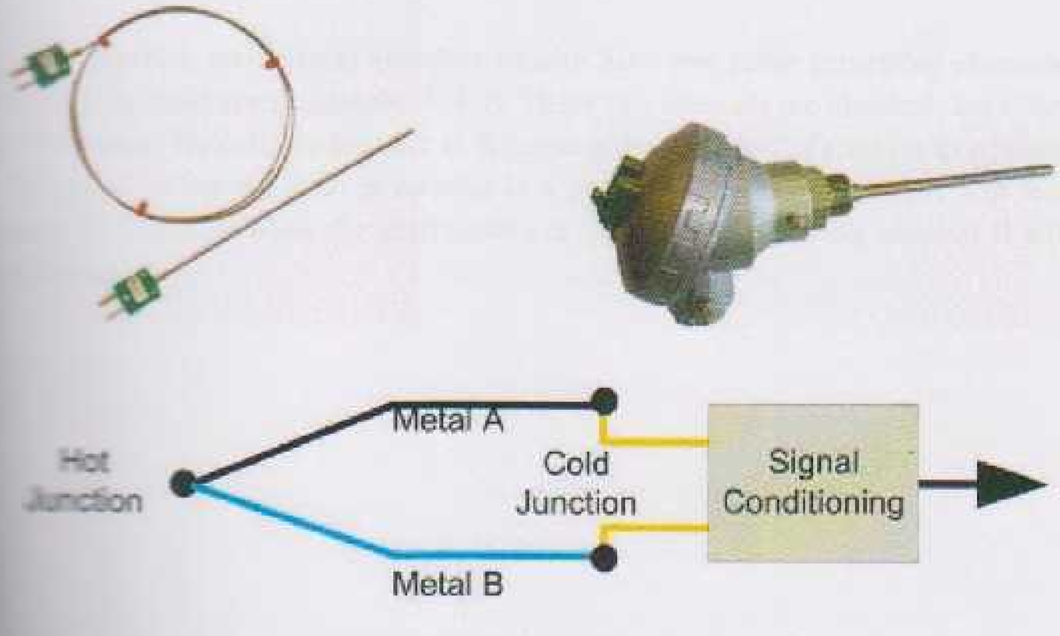



Figure (3.13): Example of Thermocouple devices.

### 3.2.4.2: Encoder sensor

Figure (3.14) shows a picture of a typical incremental encoder, which is normally attached to the shaft of a rotating machine. Usually, an encoder is used to determine the speed of the machine and the direction of rotation. As the machine rotates, the incremental encoder produces a series of square wave pulses. The number of pulses produced by the incremental encoder during one complete revolution of the attached shaft is referred to as the encoder resolution. Internally, incremental encoders operate by rotating a glass disk in the path of a beam of light. The glass disk has a series of blacked out areas, or lines, on its surface as shown in Figure 15. On the opposite side of the disk resides a photo detector.

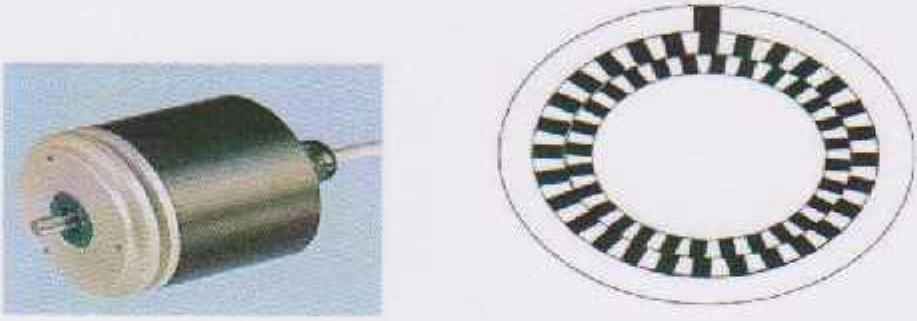


Figure (3.14): Incremental Encoder.

In practice, incremental encoders usually have two pulse generating channels, referred to as quadrature channels; A & B. These two channels are identical, but offset by 90 degrees. This allows the user to determine the direction of rotation in addition to the speed. When the shaft is rotating in a positive direction, channel A will lead channel B. However when the shaft rotates in the opposite direction, channel B will lead channel A.

## Chapter four: Protection parts

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Existence of the protection circuits is very necessary thing, also it cannot be dispensed with in any application; whether in industrial applications or in commercial applications or whatever, because the protection circuits prevent from the occurrence of any risk such as fires or shocks, also it is protecting all the human resources and material resources[12].

Several techniques commonly provide isolation when designing electronic equipment. Fuses or circuit breakers, for example, can protect both the equipment and its operator from overvoltage conditions or surges of high-voltage energy. And now will be shown equipment's which used in the protection circuits.

## 4.1: Isolation Transformer

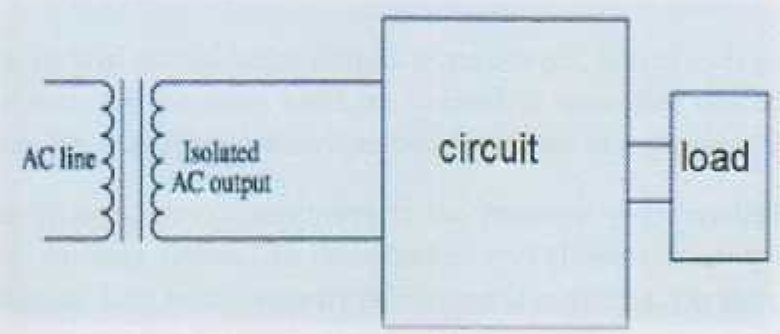
Adequate isolation between a power source and a user of electronic equipment ensures the safety of that equipment. Given the high voltages that exist in modern electronic equipment, proper isolation protects an operator from contact with excessive electrical energy should a short circuit occur in the equipment. Isolation transformers have represented a traditional solution for providing high isolation in electronic circuitry. Even with the increased use of efficient, switched-mode power supplies (SMPS), isolation transformers can improve the overall isolation of an electronic design without severe penalties in added size, weight, and cost.

Isolation transformers enable a variety of electronic systems to meet safety requirements. Such systems include medical diagnostic equipment, computer systems, and telecommunications equipment. The systems may incorporate linear power supplies, SMPS, and sometimes a combination of both. A single isolation transformer can help an electronic design meet all of its isolation requirements. With proper system design, an isolation transformer can also help reduce the size and cost of the power-electronics components following it in a design.

An isolation transformer is considerably more effective than a full-wave bridge rectifier in screening electronic equipment from high input voltages. Unfortunately, an isolation transformer can add cost, weight, size, and increased cooling requirements to a design. But it represents a reliable solution for increased isolation, even for systems employing switching power supplies.

An isolation transformer can prevent higher-order harmonic signals from degrading the performance of adjoining circuitry. This is especially important in computers or other equipment incorporating microprocessors, which rely on harmonically rich, high-frequency clock signals for their timing. Improperly isolated, these harmonic signals can appear as interference to other functions in the system, even resulting in excessive output-voltage ripple in the power supply.

Isolation transformers are specified in terms of the amount of isolation that they provide, usually given as the root-mean-square (RMS) voltage, as well as the power rating, in terms of volts-amperes (VA). Additional specifications include efficiency (in percent) and the tolerance of the voltage regulation (in percent).see figure(4.1).




Figure(4.1): Schematic of an isolation transformer in a circuit.

## 4.2: Fuses

The fuses to be considered are current sensitive devices designed to serve as the intentional weak link in the electrical circuit. Their function is to provide protection of discrete components, or of complete circuits, by reliably melting under current overload conditions.

Fuse characteristics: This characteristic of a fuse design refers to how rapidly it responds to various current overloads. Fuse characteristics can be classified into three general categories: very fast-acting, fast-acting, or Slo-Blo Fuse. The distinguishing feature of Slo-Blo fuses is that these fuses have additional thermal inertia designed to tolerate normal initial or start-up overload pulses [13].

How to choose fuse ?

1. Normal operating current.
2. Application voltage (AC or DC).
3. Ambient temperature.
4. Overload current and length of time in which the fuse must open.
5. Maximum available fault current.
6. Pulses, Surge Currents, Inrush Currents, Start-up Currents, and Circuit Transients.
7. Physical size limitations, such as length, diameter, or height.
8. Agency Approvals required, such as UL, CSA, VDE, METI, MITI or Military.
9. Fuse features (mounting type/form factor, ease of removal, axial leads, visual indication, etc.) .
10. Fuse holder features, if applicable and associated rerating (clips, mounting block, panel mount, PC board mount, R.F.I. shielded, etc.).
11. Application testing and verification prior to production.

## 4.3: Earthing system

The earthing system plays a very important role in a network. On occurrence of an insulation fault or a phase being accidentally earthed, the values taken by the fault currents, touch voltages and overvoltage's are closely related to the type of neutral earthing connection.

A solidly earthed neutral helps to limit overvoltages; however, it generates very high fault currents. On the other hand, an isolated or unearthed neutral limits fault currents to very low values but encourages the occurrence of high overvoltages.

In any installation, service continuity in the presence of an insulation fault also depends on the earthing system. An unearthed neutral allows continuity of service in medium voltage, as long as the security of persons is respected. On the other hand, a solidly earthed neutral, or low impedance-earthed neutral, requires tripping to take place on occurrence of the first insulation fault.

The extent of the damage to some equipment, such as motors and generators having an internal insulation fault, also depends on the earthing system.

The choice of earthing system, as much in low voltage as in medium voltage, depends both on the type of installation and network. It is also influenced by the type of loads, the service continuity required and the limitation of the level of disturbance applied to sensitive equipment.

## 4.4: Circuit breaker (MCB)

A circuit breaker is an automatically operated electrical switch designed to protect an electrical circuit from damage caused by overload or short circuit. Its basic function is to detect a fault condition and interrupt current flow.

An MCB is a modern alternative to fuses used in Consumer Units (Fuse Boxes). They are just like switched which switch off when an overload is detected in the circuit. The advantage of MCBs over fuses is that if they trip, they can be reset , they also offer a more precise tripping value. See figure (2.16).

Figure (4.3): Single phase circuit breaker (MCB).

## 4.5: Over load

Many people plan their motor protection around a fuse or breaker. Fuses and breakers look at short-circuit current that happens after the motor has failed.

Their job is to protect the power system from damage due to the level of short-circuit current. When they go, it's already too late for your motor. For motor protection, you should look to the overload relay in your starter.

Overload relays (figure 4.4) are defined by their protection Class. Protection is based on the amount of time it takes the overload to trip at locked rotor current. A Class 10 overload is faster that a Class 20 or Class 30 overload.

Figure (4.4): Motor Overload Protection

Another important feature is the overload ability to recognize a single-phase condition and trip faster. Many overloads have two trip curves covering symmetrical or single-phase tripping; most replaceable heater overload relays do not.

The biggest mistake I see is the application of overload protection at the motor nameplate current. That assumes the motor is completely loaded. Many motors run at 75% to 90% load. The overcurrent protection should be applied slightly above RUNNING load current, not full load current. This allows the overload relay to tell you something is wrong when you exceed normal running load current but before you exceed full load current. Take care not to get too close to the running load current in order to reduce nuisance tripping.

## 4.6: Heat sink

In many electronic applications, temperature becomes an important factor when designing a system. Switching and conduction losses can heat up the silicon of the device above its maximum Junction Temperature (Tjmax) and cause performance failure, breakdown and worst case, fire. Therefore the temperature of the device must be calculated not to exceed the Tjmax. To design a good Thermal Management solution, the Tj should always be kept at the lowest operating temperature.

Heat sinks figure (4.5) are devices that enhance heat dissipation from a hot surface, usually the case of a heat generating component, to a cooler ambient, usually air. For the following discussions, air is assumed to be the cooling fluid. In most situations, heat transfer across the interface between the solid surface and the coolant air is the lead efficient within the system, and the solid-air interface represents the greatest barrier for heat dissipation. A heat sink lowers this barrier mainly by increasing the surface area that is in direct contact with the coolant. This allows more heat to be dissipated and/or lowers the device operating temperature. The primary purpose of a heat sink is to maintain the device temperature below the maximum allowable temperature specified by the device manufacturer [14].

When selecting a heat sink, it is necessary to classify the air flow as natural, low flow mixed, or high flow forced convection.

**Heat-Sink Types :**

1.**Stampings**: Copper or aluminum sheet metals are stamped into desired shapes. They are used in traditional air cooling of electronic components and offer a low cost solution to low density thermal problems. They are suitable for high volume production, and advanced tooling with high speed stamping would lower costs .
2. **Extrusions**: These allow the formation of elaborate two-dimensional shapes capable of dissipating large heat loads.
3. **Bonded/Fabricated Fins:** Most air cooled beat sinks are convection limited, and the overall thermal performance of an air cooled heat sink can often be improved significantly if more surface area can be exposed to the air stream .
4. **Castings**: Sand, lost core and die casting processes are available with or without vacuum assistance, in aluminum or copper/bronze.
5. **Folded Fins**: Corrugated sheet metal in either aluminum or copper increases surface area and, hence, the volumetric performance.

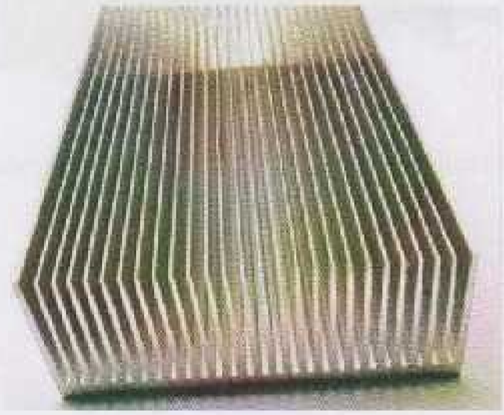


Figure (4.5): Aluminum heat sink.

## 4.7: Cooling fan

Fan motor is widely used to extend life of your system by cooling off heat of the system that many electrical components are mounted in a very high density and dissipating heat. Figure(4.6) show cooling fan shape.

We can roughly divide fan into two types which are AC and DC. AC fan have this prosperities: High performance, High reliability, and Safety. But DC fans have the following prosperities: Low power consumption, High performance, Low vibration, Low leakage of flux, High reliability.

To choose the suitable fan, you should followed the following steps:

1) Determining of your system specifications and conditions.
2) Calculating the Required Air flow for Cooling.
3) Selecting the Fan.
4) Confirming the Selected Fan.

Figure(4.6): Cooling fan that using in heaters .

# Chapter five: Design of the system

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## 5.1:Motors parameter:

We collect the name plate for motors that used in production line in table (5.1).

Table(5.1): Name plates of the motors.[15]

| Motor | V ▲/Y | F/Hz | P/kW | rpm | A ▲/Y | Connection |
|---|---|---|---|---|---|---|
| Heat exchanger for heaters | 220/380 | 50 | 2.2 | 2840 | -/4.9 | Y |
| Screws motors | 400/690 | 50 | 37 | 2950 | 64.2/37 | ▲ |
| Heat exchanger for Screws motors | 380/420 | 50 | 0.55 | 930 | 1.8/1.7 | ▲ |
| Vacuum motor | 380/420 | 50 | 2.2 | 2890 | 4.3/3 | ▲ |
| Feeder motor | 230/380 | 50 | 0.72 | 1380 | 3.3/1.9 | Y |
| Tracker motor | 230/400 | 50 | 2.2 | 1420 | 8.4/4.8 | Y |
| Fan motors | 220/110 | 50 | 1 | 1500 | 1.6 | Y |

**Calculations of motors**

A-Heat exchanger for heaters.

1) $OL = In = 4.9A$ eq.(5.1)

2) $MCB = 1.25 * In$ eq.(5.2)

$= 1.25 * 4.9 = 6.1A$

3) Size a contactor or frequency converter $= 1.1 * Pin\ 'kW'$ eq.(5.3)

$= 1.1 * 1.8 = 2kW$

We complete the calculations processes for all motor and then putting the values in table (5.2).

Table (5.2): Sizing a protection elements.

| Motor | OL/A | MCB/A | Contactor size kW |
|---|---|---|---|
| $Fan_1$ | 1.6 | 2 | 1 |
| $Fan_2$ | 1.6 | 2 | 1 |
| $Fan_3$ | 1.6 | 2 | 1 |
| $Fan_4$ | 1.6 | 2 | 1 |
| Vacuum motor | 4.3 | 6 | 2.5 |
| Heat exchanger for heaters | 4.9 | 6 | 2 |
| Heat exchanger for Screws motors | 1.8 | 2 | 1 |

## 5.2: Heaters parameter

There are twelve heater in the system and all heater work in the same power and voltage, but the twelve heaters consists from three types that depend on different temperatures. Table(5.3) explain the power and voltage values for heaters.

Table(5.3): Name plates of the heaters [15].

| Heater | Power/kW | Voltage/V |
|---|---|---|
| Three phase heater | 9 | **200** |
| Single phase heater | 2 | **220** |

**Calculations of heater:**

A) Three phase heater:

1- $Current = \frac{Power\ (w)}{Voltage(v)} = \frac{9000}{220} = 40A$ eq.(5.4)

2- $Fuse\ size = 40A$

3- Size a $solid\ state\ relay = 1.6 * current = 1.6 * 40 = 64A$ eq.(5.5)

B) Single phase heaters:

1- $Current = \frac{P}{V} = \frac{2000}{220} = 9A$

2- $Fuse\ size = 9A$

3- Size a $solid\ state\ relay = 1.6 * current = 1.6 * 9 = 15A$

## Chapter six: Analysis of the system

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### 6.1: Block Diagram

The work principle of production line depended on the machine outputs, where we have some levels to complete production operation, figure (6.1) explained the general block diagram and show the main motors and actuators that are sharing on the same PLC and HMI. In the following levels explained in block diagram how levels work.

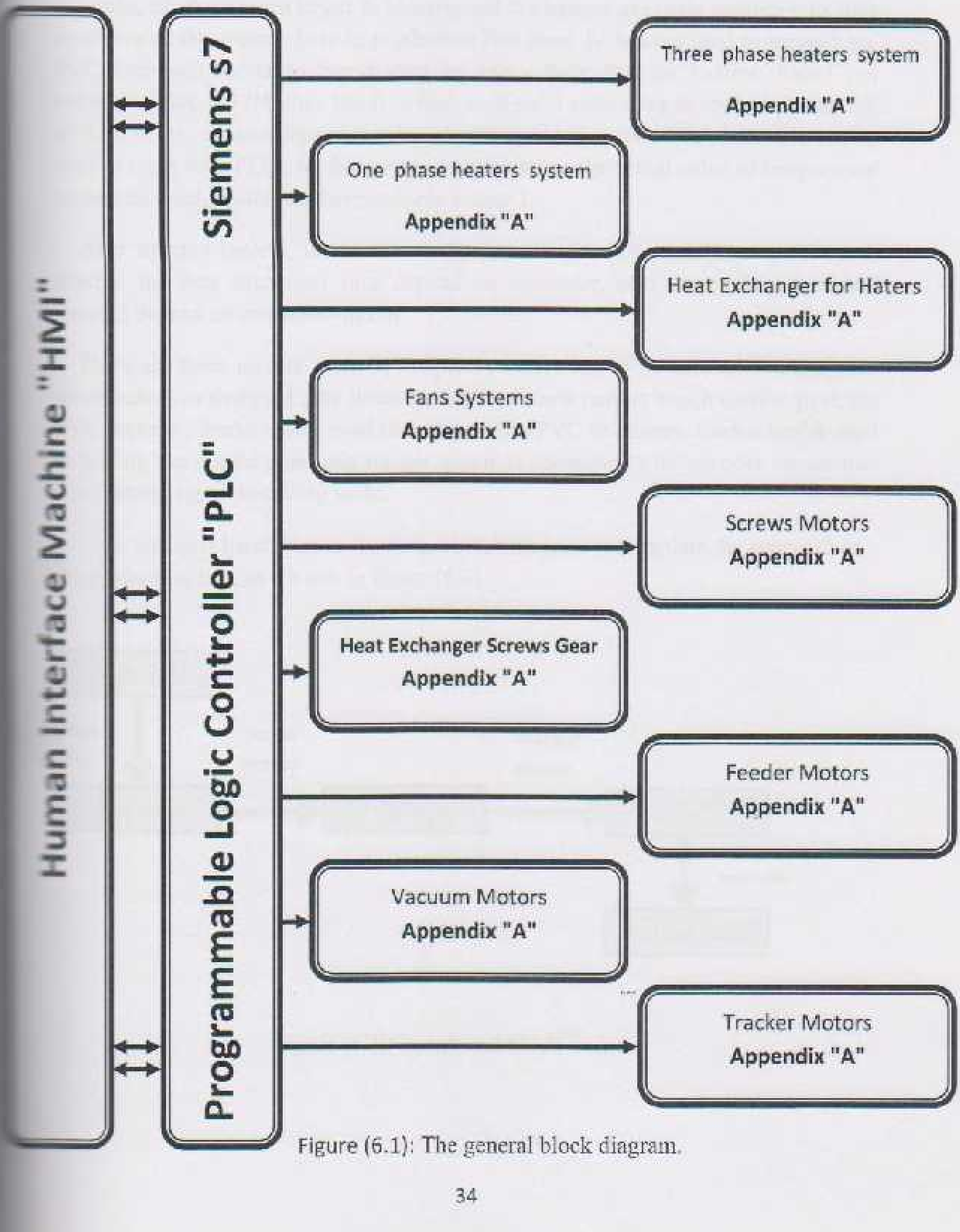



Figure (6.1): The general block diagram.

As we see in figure (6.1) there are several outputs: heaters, screw motor, cooling fans, heat exchanger for screw gear, and heat exchanger for heaters, feeder motor, and tracker motor.

And for more details about the outputs and the main processes that relate with outputs, you can refer to **appendix A** which represent a block diagram for the system.

The outputs in block diagram are arranged as a sequence dependent on the priority of works, block diagram begin in heaters, and the heaters are main condition to start processes of the system, here in production line there 12 heaters used to convert the PVC from solid state to liquid state by using three type of heaters: barrel (on cylinder), joint, die (Heaters head). where used solid state relay to control in running of the heaters , heaters depend on special sensor which is called thermocouple sensor used as input with PLC , by this sensor you can know the actual value of temperature on heaters (each heater has thermocouple sensor ).

After running heaters, the heat exchanger works directly, to save temperature of heaters. the heat exchanger runs depend on contactor. also the cooling fans and vacuum depend on contactors to run.

There are three motors work by frequency converter, to be able on changing the speed values as designed , the three motors are: screw motors which used to push the PVC material, feeder motor used to transport the PVC to heaters, tracker motor used to pulling the plastic pipe. and tracker motor is connected with encoder sensor that send cutting signal to cutting tools.

In the other hand there is functional block diagram that explain the approach of the production line, as we saw in figure (6.2).

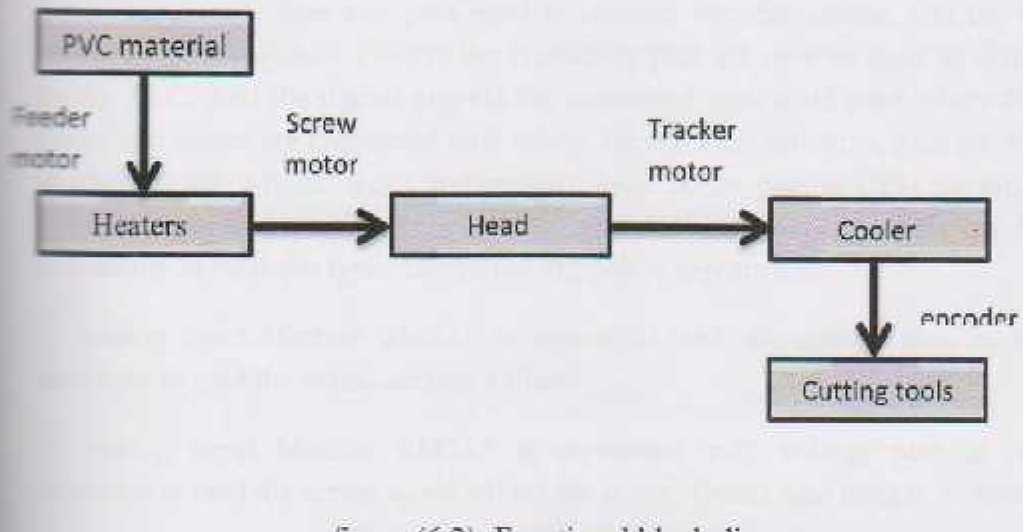



figure (6.2): Functional block diagram.

## 6.2: Flow chart

We can see the sequence of operations, that explain the steps of production line, and **appendix B** shown these steps as flow chart.

Through the graph it is clear to us that the operation of heaters is the main condition for the start of the work of the production line, and then the screw motor is running as long as the temperature of the heaters higher than 150 degrees. after these two phases there are several outputs run to complete the work properly, such as cooling fans and heat exchangers. Then comes the feeder motor running phase which does not work only if it reaches the speed of the screw to 60 rpm, and thus works vacuum. And then you can run the tracker. However, the tracker works manual or Super automatic where it works manually in case of maintenance and cleaning. It should be noted that there encoder sensor is used to measure the length of PVC pipe, which sends a signal to cutter. And so on for every time.

## 6.3: Control Circuit design

Control circuit used to describe the basis of the work, where the PLC considered the main part of the control circuit, that is made up of several Modules; whether (Digital) or (Analog). And as we see in **appendix C** which explains several things: first, it shows the presence of isolation transformer that separate between 380V AC and 220V AC to protect the power supplies, whether PLC power supply or another power supply. Also used circuit breaker for protection processes. secondly, the phase line which transport from page one to page six to run the contactors by signal send for (normally open) relay, and contactors work only if the overload of (normally closed). Thirdly, CPU of PLC is consisting from digital (inputs/outputs) and analog pins, the digital inputs are: first two pins used to connect encoder sensor, and the third pin connect with emergency switch, the remaining pins are used to send an alarm signal for the PLC. And the digital outputs are connected with solid state relays for twelve heater and others are connected with relays for different actuators, also we would use another module (digital input and output); because the pins in CPU are not enough. Fourthly, the input and output analog modules are used for different functions depending on modules type. The following points explain this:

1) Analog Input Module 'EM231' is connected with the current pins in frequency converter to read the actual current values.

2) Analog Input Module 'EM235' is connected with voltage pins in frequency converter to read the actual speed values for screw, feeder, and tracker motors.

3) Analog Output Module 'EM232' is connected with frequency converter, which it used to give the set speed value for motors.

4) The last three modules (Temperature Module1 'EM231') are used to read the actual temperature in heaters, where it connected with thermocouple sensor.

It should be pointed to the use of an insulator wires for connection between modules and between frequency converters; in order to keep the electrical signal from being lost as a result of a specific defect, such as the impact of the magnetic field.

## 6.4: Power Circuits design

The power circuit is representing the motors and heaters in the production line, it should has important parts cannot neglected, like main circuit breakers, overloads, fuses, and frequency converter. you can refer to **appendix C** to understand it.

The motors in power circuit are separating for two sections: motors run by contactors and motors run by frequency converter, this is depending on application, the frequency converter use in analog applications, but the contactors are using in digital applications.

## 6.5: PLC Implementation

We will address in this section a group of job titles that relate to the controller and programming language.

### 6.5.1: PLC Hardware configuration


Figure (6.3): Hardware configuration of PLC.

When we connect any thermocouple sensor in PLC device, we should know the type of that sensor, where exist many type sensor such as; J, K, T, E, R, S, and N. because each sensor has different hardware in DEP-switch at temperature module. And you can see the different here in table (6.1).

Table (6.1): Thermocouple type to select configuration.

| Thermocouple type | $SW_1$ | $SW_2$ | $WS_3$ |
|---|---|---|---|
| J | 0 | 0 | 0 |
| K | 0 | 0 | 1 |
| T | 0 | 1 | 0 |
| E | 0 | 1 | 1 |
| R | 1 | 0 | 0 |
| S | 1 | 0 | 1 |
| N | 1 | 1 | 0 |
| +/-80mV | 1 | 1 | 1 |

Now, we need to choose the suitable ranges for your module model ( UN 235-0KD22-0XA0) to full input, where you can do that by using DIP- switch, depending on table(6.2) to be able chose.

Table (6.2): DIP switches configuration to select the suitable range for Analog output module.

| Modules model | $WS_1$ | $WS_2$ | $WS_3$ | $WS_4$ | $WS_5$ | $WS_6$ | Full Input |
|---|---|---|---|---|---|---|---|
| UN 235-0KD22-0XA0 | 1 | 0 | 0 | 1 | 0 | 1 | (0 – 50) mV |
| | 0 | 1 | 0 | 1 | 0 | 1 | (0 – 100) mV |
| | 1 | 0 | 0 | 0 | 1 | 1 | (0 – 500) mV |
| | 0 | 1 | 0 | 0 | 1 | 1 | (0 – 1) V |
| | 1 | 0 | 0 | 0 | 0 | 1 | (0 – 5) V |
| | 1 | 0 | 0 | 0 | 0 | 1 | (0 – 20) mA |
| | 0 | 1 | 0 | 0 | 0 | 1 | (0 – 10) V |
| | 1 | 0 | 0 | 1 | 0 | 0 | (– +25) mV |
| | 0 | 1 | 0 | 1 | 0 | 0 | (– +50) mV |
| | 0 | 0 | 1 | 1 | 0 | 0 | (– +100) mV |
| | 1 | 0 | 0 | 0 | 1 | 0 | (– +250) mV |
| | 0 | 1 | 0 | 0 | 1 | 0 | (– +500) mV |
| | 0 | 0 | 1 | 0 | 1 | 0 | (– +1) V |
| | 1 | 0 | 0 | 0 | 0 | 0 | (– +2) V |
| | 0 | 1 | 0 | 0 | 0 | 0 | (– +5) V |
| | 0 | 0 | 1 | 0 | 0 | 0 | (– +10) V |

The CPU use in our project is CPU 224XP. And in table (6.3) explain the modules that use with CPU and specified the modules addresses.

Table (6.3): PLC modules addresses

| CPU 224XP | | EM223 | | EM231 | EM235 | EM232 | EM231 | EM231 | EM231 |
|---|---|---|---|---|---|---|---|---|---|
| A/D-I | A/D-O | D-O | D-I | AIW4 | AIW12 | AQW8 | AIW20 | AIW28 | AIW36 |
| I0.0 | Q0.0 | Q2.0 | I0.0 | AIW6 | AIW14 | AQW10 | AIW22 | AIW30 | AIW38 |
| I0.1 | Q0.1 | Q2.1 | I0.0 | AIW8 | AIW16 | | AIW24 | AIW32 | AIW40 |
| I0.2 | Q0.2 | Q2.2 | I0.0 | AIW10 | AIW18 | | AIW26 | AIW34 | AIW42 |
| I0.3 | Q0.3 | Q2.3 | I0.0 | | | | | | |
| I0.4 | Q0.4 | Q2.4 | I0.0 | | | | | | |
| I0.5 | Q0.5 | Q2.5 | I0.0 | | | | | | |
| I0.6 | Q0.6 | Q2.6 | I0.0 | | | | | | |
| I0.7 | Q0.7 | Q2.7 | I0.0 | | | | | | |
| I1.0 | Q1.0 | Q3.0 | I0.0 | | | | | | |
| I1.1 | Q1.1 | Q3.1 | I0.0 | | | | | | |
| I1.2 | Q1.2 | Q3.2 | I0.0 | | | | | | |
| I1.3 | Q1.3 | Q3.3 | I0.0 | | | | | | |
| I1.4 | Q1.4 | Q3.4 | I0.0 | | | | | | |
| I1.5 | Q1.5 | Q3.5 | I0.0 | | | | | | |
| I1.6 | Q1.6 | Q3.6 | I0.0 | | | | | | |
| I1.7 | Q1.7 | Q3.7 | I0.0 | | | | | | |
| AIW0 | AQW0 | | | | | | | | |
| AIW2 | AQW2 | | | | | | | | |

## 6.5.2: Symbol table

Through a symbol table ( in **appendix D** ) we can know the variables of the system and understand what each variable meaning, and we can refer to the address of variable in PLC program by using it.

### 6.5.3: PLC program

The extruder program is existing in **Appendix E** ,you can refer to it.

## 6.6: HMI Implementation

The HMI is the screen which used to connect between the system operations and the workers in the production line. It consists of several screens: the main screen, heaters screen, maintenance screen, inverter screen, cutting screen, alarm screen, and maintenance screen. And each screen has specific function and works, the screens of HMI is simulation for the program in PLC.

Figure(6.4) explained the main screen that include the production line ( extruder) with main components , such as ; heaters, cooling fans, vacuum, heat exchanger, motors, feeder motor, and screw motor. Also contains on switches that moving from main screen to other screens. In main screen exist push-button used to run all program, and without it the machine will not work.

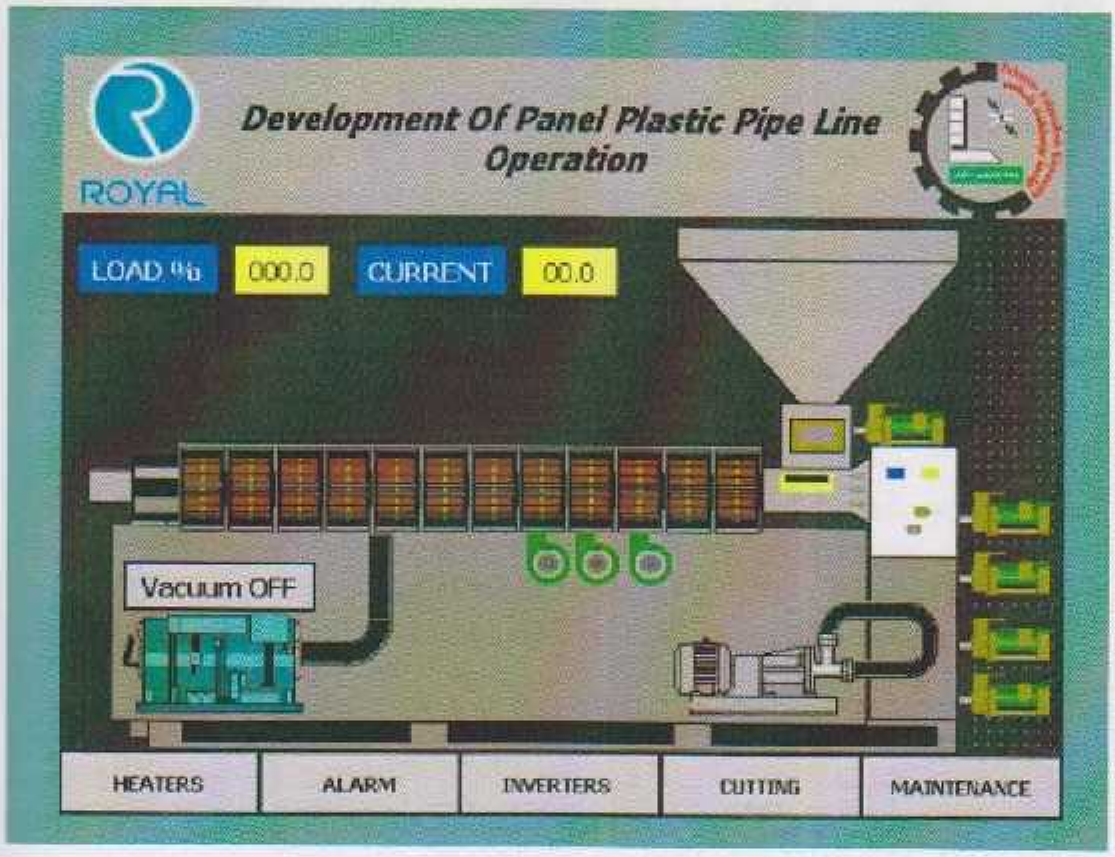



Figure (6.4): Main screen.

Figure (6.5) show the heaters measurement screen, this screen consists of push-buttons for running heaters, reference and actual values of the heaters temperature, include also on push-button used to set reference temperature value for all heaters, this way only used in the initial stage of running the production line, and if you want to enter the reference temperature value for specific heaters, you must not use set value push-button.

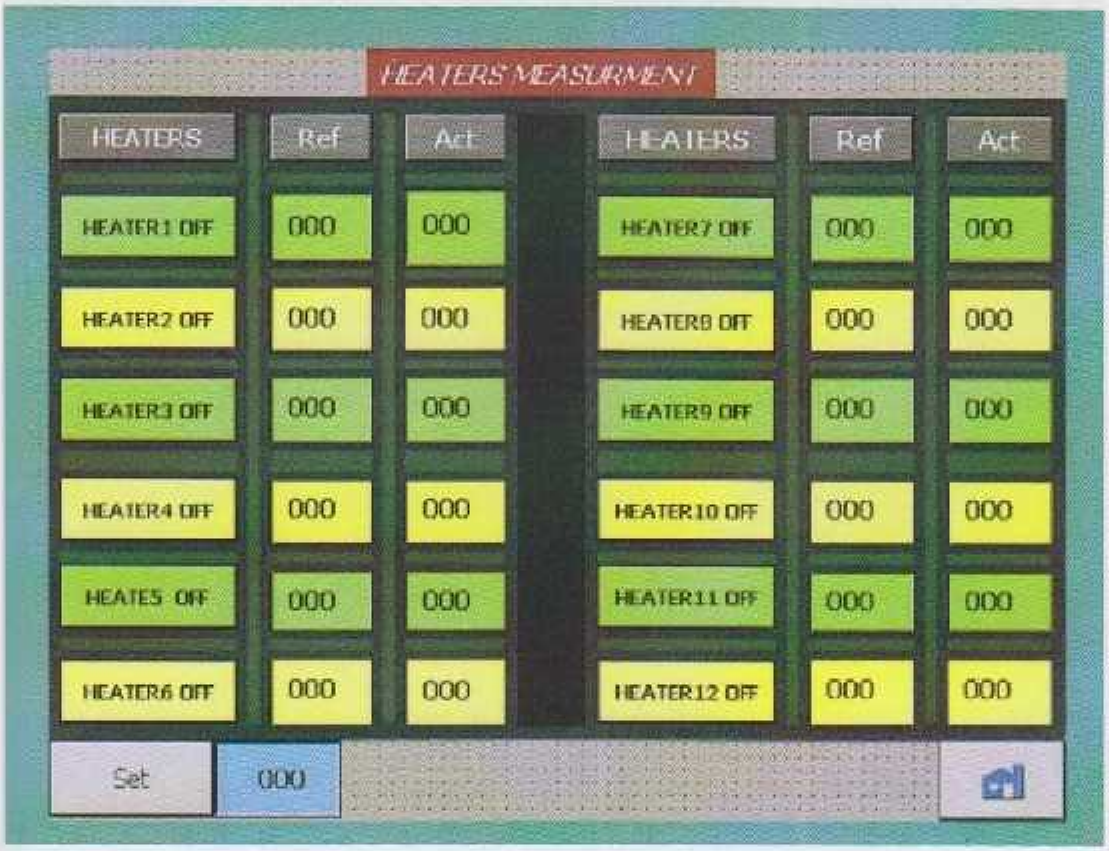



Figure (6.5): The heaters measurement screen.

We can control the speed of the motors by using frequency converter and as shown in figure (6.6) there are three motors. The reference speed value and actual speed value must be almost equal. Also exist two ratios: the first, between screw and feeder. Second, between screw and tracker. And that ratio using for calibration processes.

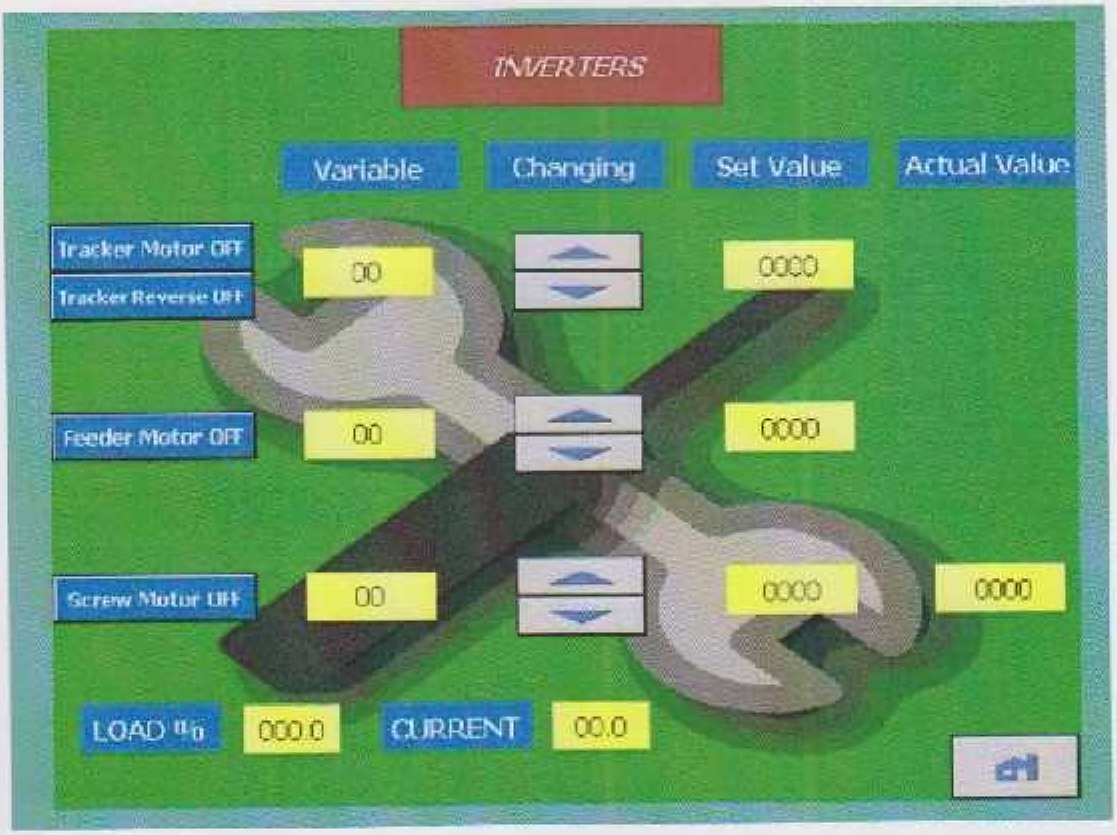



Figure (6.6): Inverter screen.

Figure (6.7) explain the responsibility of the screen that runs motors on or off; such as, vacuum, heat exchangers. Where motors maybe worked automatically or manually. Depending on the conditionals work.

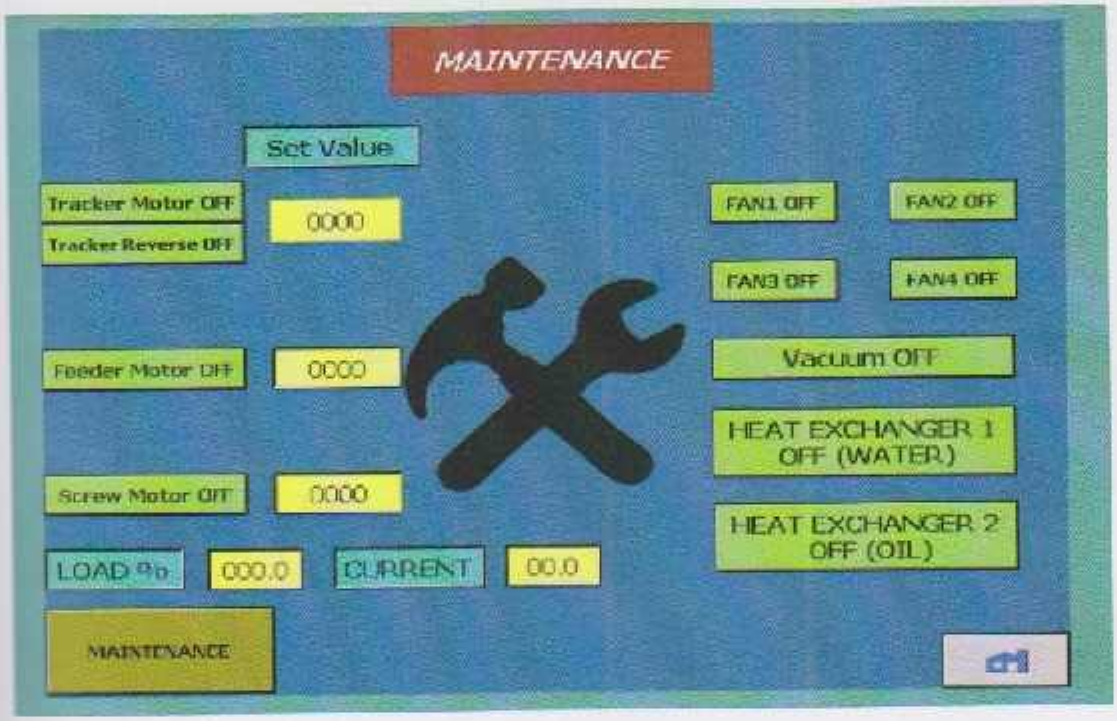



Figure (6.7): Maintenance screen.

After the completion of the previous stages, comes the stage that cut plastic pipe which happened by using encoder, figure (6.8) shown how to enter the reference distance which is called desired distance value, at this value the encoder will run cutting tool.

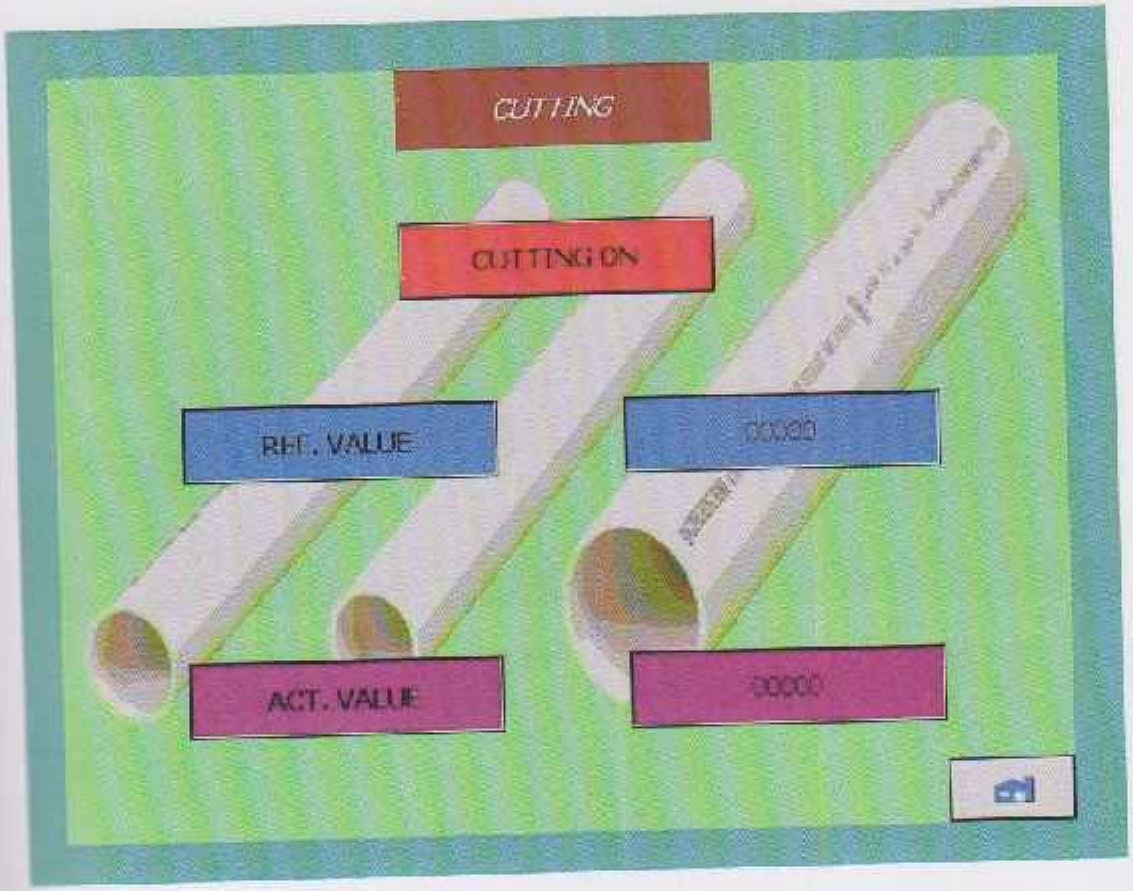



Figure (6.8): Cutting screen.

Figure (6.9) explain the list of errors that may be happened through the work. Where the error signal appear beside the error when it happens. There is a lamp which is lit when the errors happen.

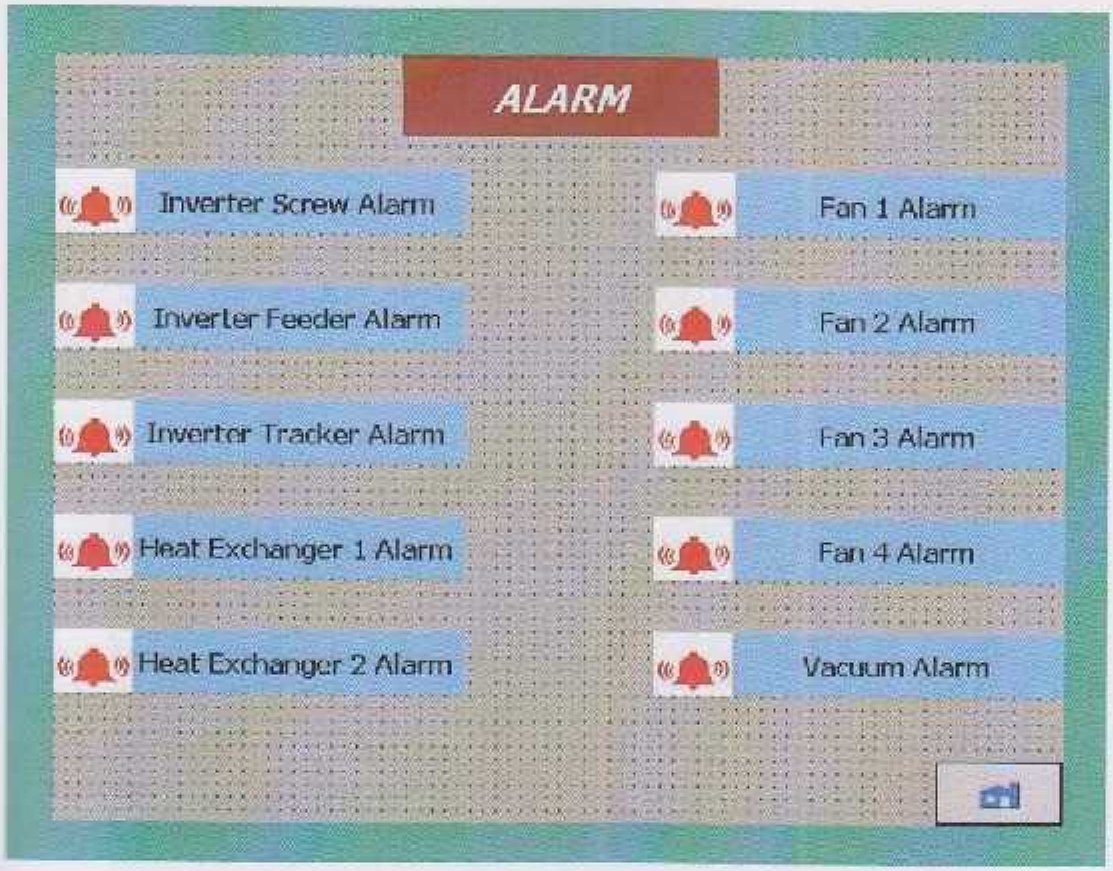



Figure (6.9): Alarm screen.

### 6.7: Practical circuit of the system

In this section we will explain the electrical and mechanical part in the system, and we will compare between the previous shape and the present shape.

Figure (6.10) display the traditional components that use control panel, where the panel consists of many push-buttons, measurement devices, and many unimportant parts in the new panel. And as shown in figure (6.11) that explain the Chaos inside panel.

Figure (6.10): The old control panel.

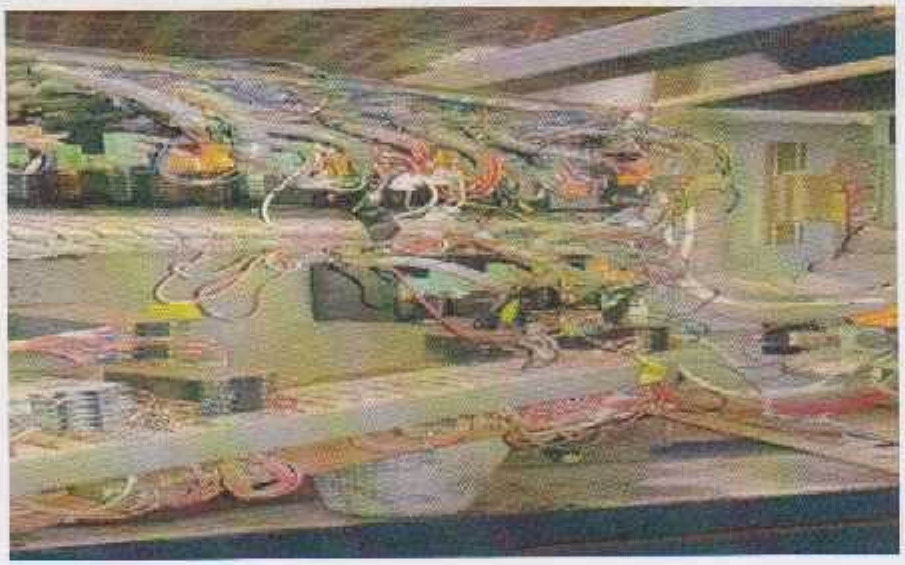


Figure (6.11): The connection inside the control panel.

After we design the control circuit and power circuit we began using many steps, the first step is building and choosing the suitable Electrical cabinet to complete the next steps. Secondly, collecting all the parts that will be used in connection ,thirdly connecting the power circuit and control circuit , fourthly we should check the connection by using the digital multi-meter (DMM) device , finally putting the symbols for each parts. Figure (6.12) show that.

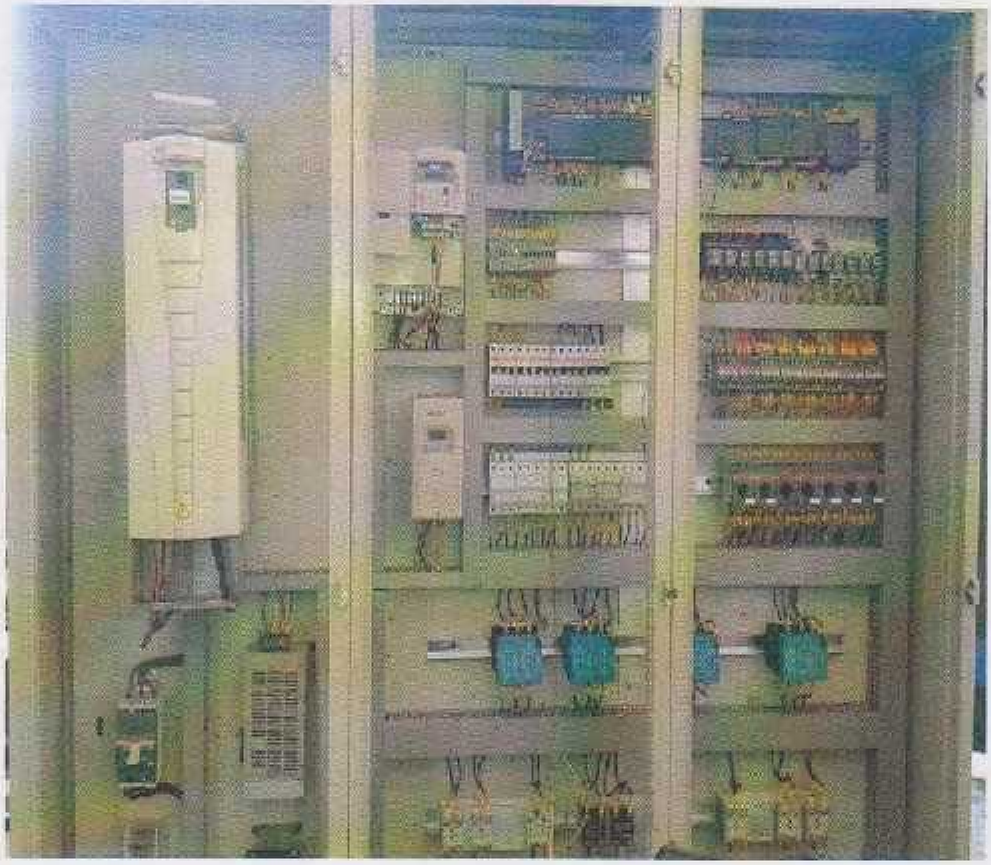


Figure (6.12): Electrical cabinet .

## Chapter seven: Results and Conclusion

## Conclusion

After we finished from our project, conclusions are:

Any production line consist of several functions and equipment's, so analysis the production line and know the system parts ( inputs, processes, output) considered the important step in the project. And separate the project for many section is help us to achieve the main points, for example; temperature calibration and speed control. And then we collect these sections to form the complete project.

## Results

The production line processes improved from classic controlling to modern technology controlling, by using the PLC program and HMI screen. Now, most of the previous problems in production line has been disposed of, the maintenance process became easy, and the tracking of wire is not difficult as it were. In addition, when the production line is running, the workers will calibrate the machines without big effort, therefore saved time.

The controlling includes all the parts in production line such as motors, vacuum pump, heaters, and pullers. Only by the human machine interface (HMI).

We are able to understand and analyze PLC programs and the machines, as well as our ability to engage in the factories and the industrial labor market, and we have ability to leader any other project, and this the best result.

# Challenges and Recommendations

## Challenges

We faced many challenges during the implementation phase of the project, and we tried to get rid of these challenges as follows:

1) Hardware configuration of PLC.
   The PLC-S7 200 is configuring without need to do that as other PLCs.
2) The HMI screen.
   We faced several of challenges in HMI: First, we spent many of time to brought the HMI program. Secondly, choose suitable series cable which is transporting the data from PLC to HMI and vice versa. Finally, error in the transporting process due to difference in baud rate between PLC and HMI.
3) Frequency converters.
   We used three different types of frequency converter, and each frequency converter has special software.
4) PLC program
   Converter process of data from real to integer and vice versa by using scaling library.

## Recommendations

We have many recommendations that can contribute to the provision of improvements to the project, could have been done, but this need many time. These recommendations can be summarized in the following points:

1) Use Tachogenerator sensor to measure the motors speed instead of used frequency converter because it is not accuracy like Tachogenerator.
2) Add the synchronization process between the main motors: screw, feeder, tracker, because this process make the controlling process is very simple.
3) To complete implementing the PLC program by adding sika machine.

## References


[1] http://www.plasticseurope.org

[2] PLASTIC FORMING INDUSTRY, HANDY MANUAL, Output of a Seminar on Energy Conservation in Plastic Forming Industry,1995.

[3] WalidEmar, Hussein Sarhan, Rateb Al-Issa, IssamTTrad& Mahmoud Awada, V/F Control of Squirrel Cage Induction Motor Drives Without Flux or Torque Measurement Dependency, International Journal of Computer Applications (0975 – 8887).

[4] Dr. Lutfi R. Al-Sharif, AC Induction Motors, in Mechatronics System Design (Rev 3.0, 14/1/2010).

[5] Dr. Walter Umrath, Fundamentals of Vacuum Technology, Cologne, June 2007.

[6] R. K. Shah and D. R SekulibUniversity of Kentucky, HEAT EXCHANGERS, Delphi Harrison Thermal Systems, New York.

[7] A. Fosco, Chillers and Mold Temperature Controllers: A Guide to Usage, Plastics Auxiliaries, March 1999, p. 24.

[8] http://ubasics.com/adam/electronics/doc/phasecon.shtml

[9] STEP 2000 Basics of PLCs, SIEMENS.

[10] http://en.wikipedia.org/wiki/Contactor

[11] Jon S. Wilson, Sensor Technology Handbook, united states of America , 2005.

[12] Oleg Semenov‹HosseinSarbishaei‹ManojSachdev, ESD Protection Device and Circuit Design for Advanced CMOS Technologies,2008.

[13] FUSEOLOGY Selection Guide Fuse Characteristics,Terms and Consideration Factors.

[14] Seri Lee, HOW TO SELECT A HEAT SINK, Laconia, New Hampshire 03247

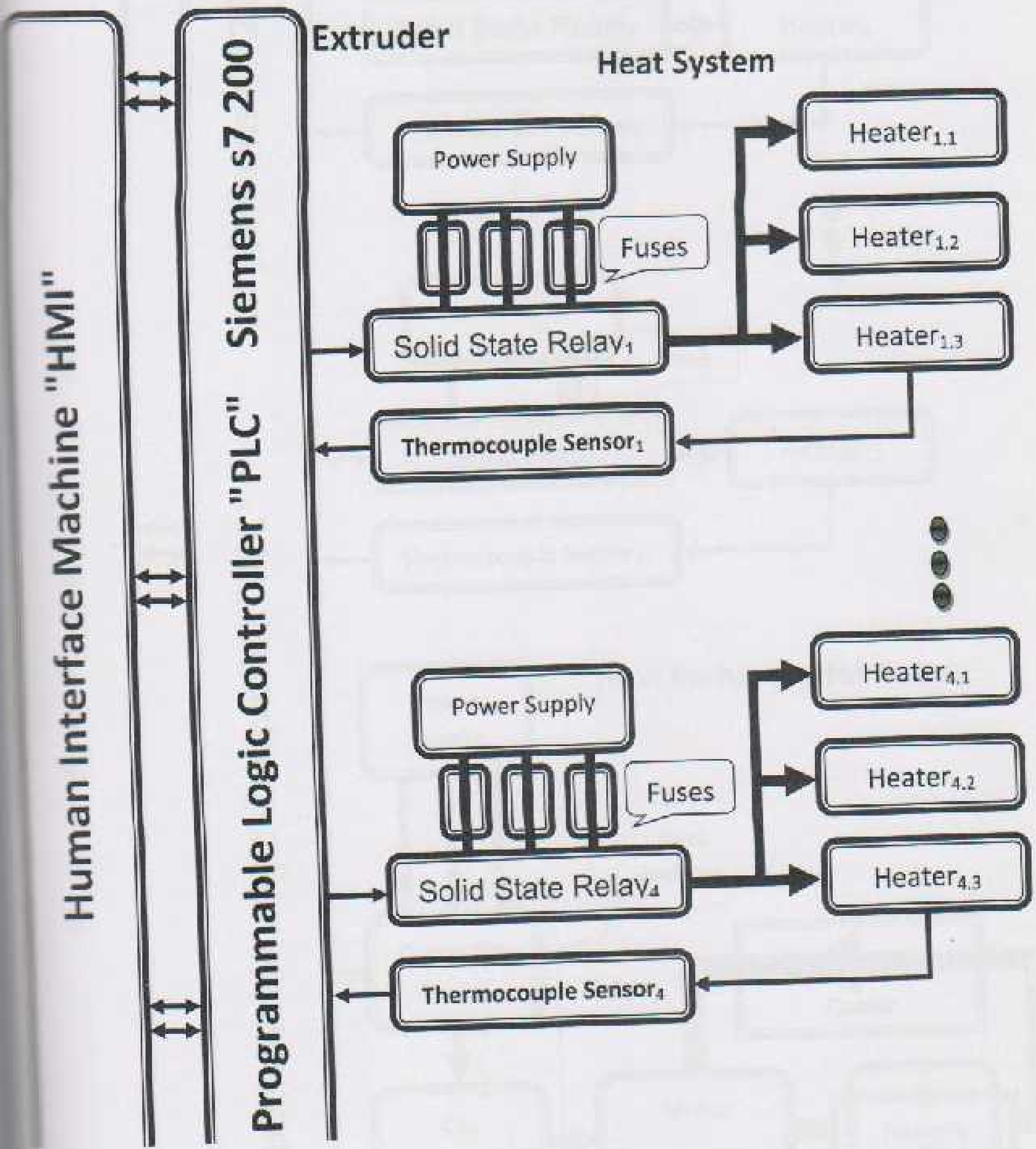
[15] the Royal Industrial Co.,

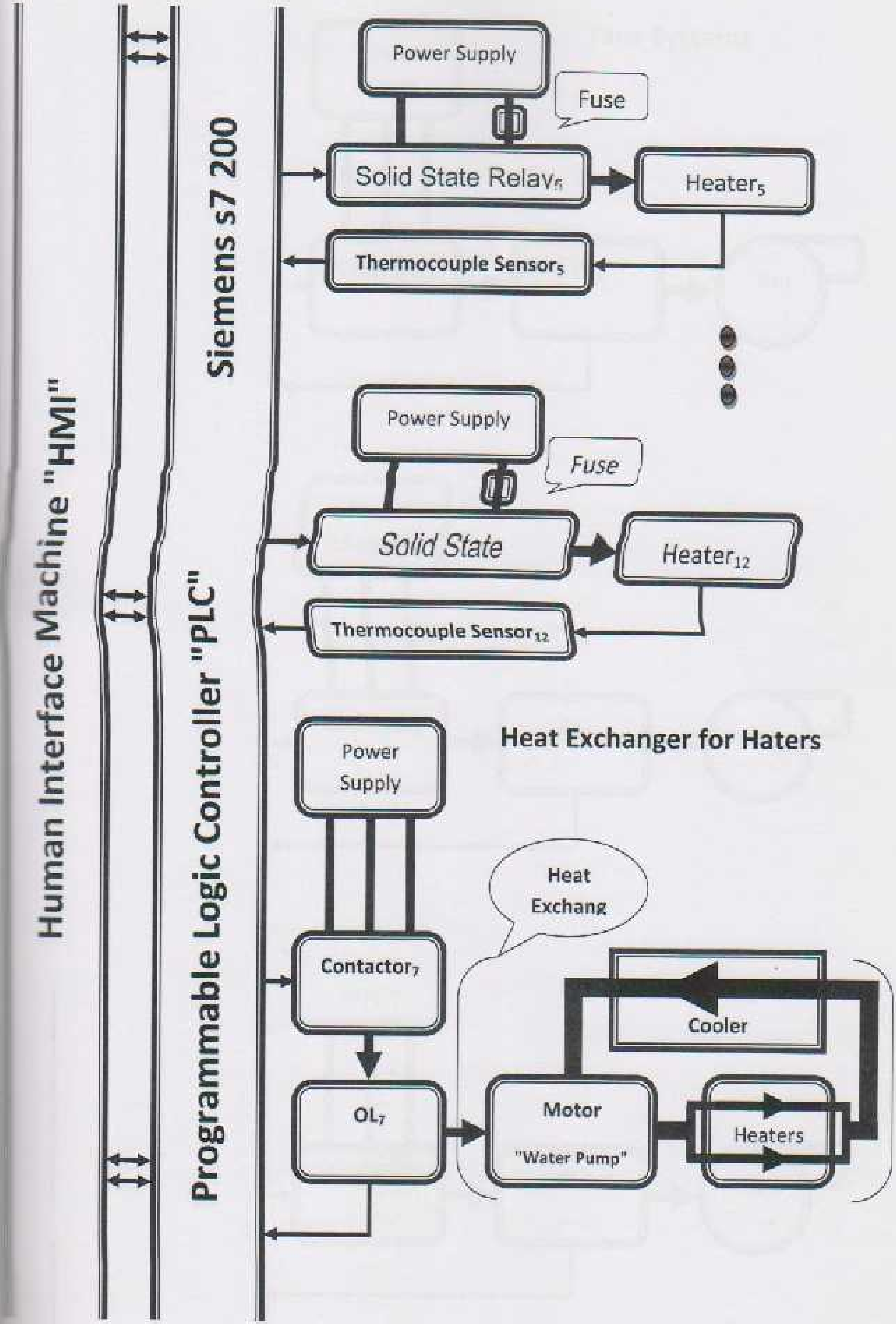
[16] https://support.industry.siemens.com

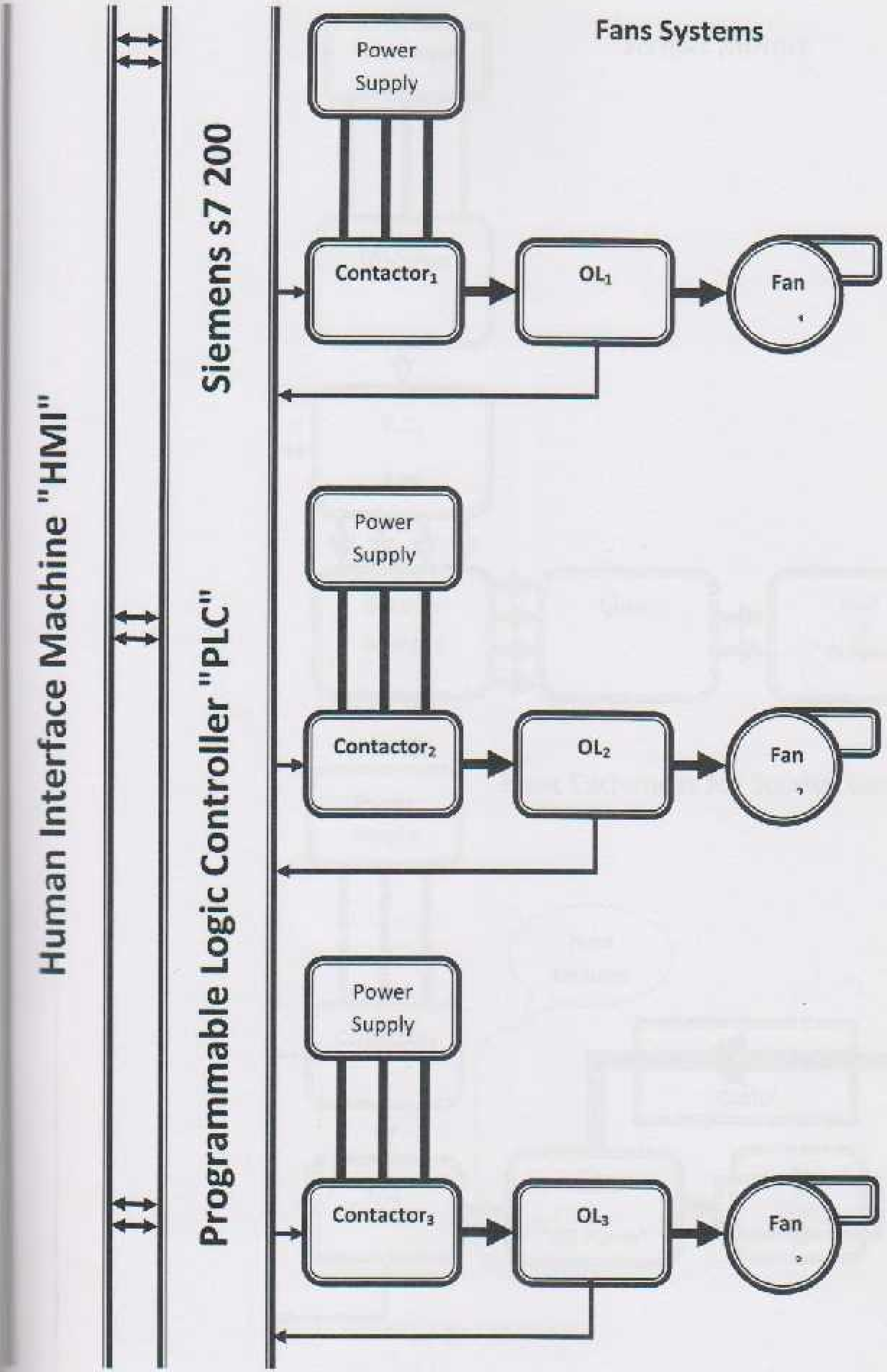
## Appendices

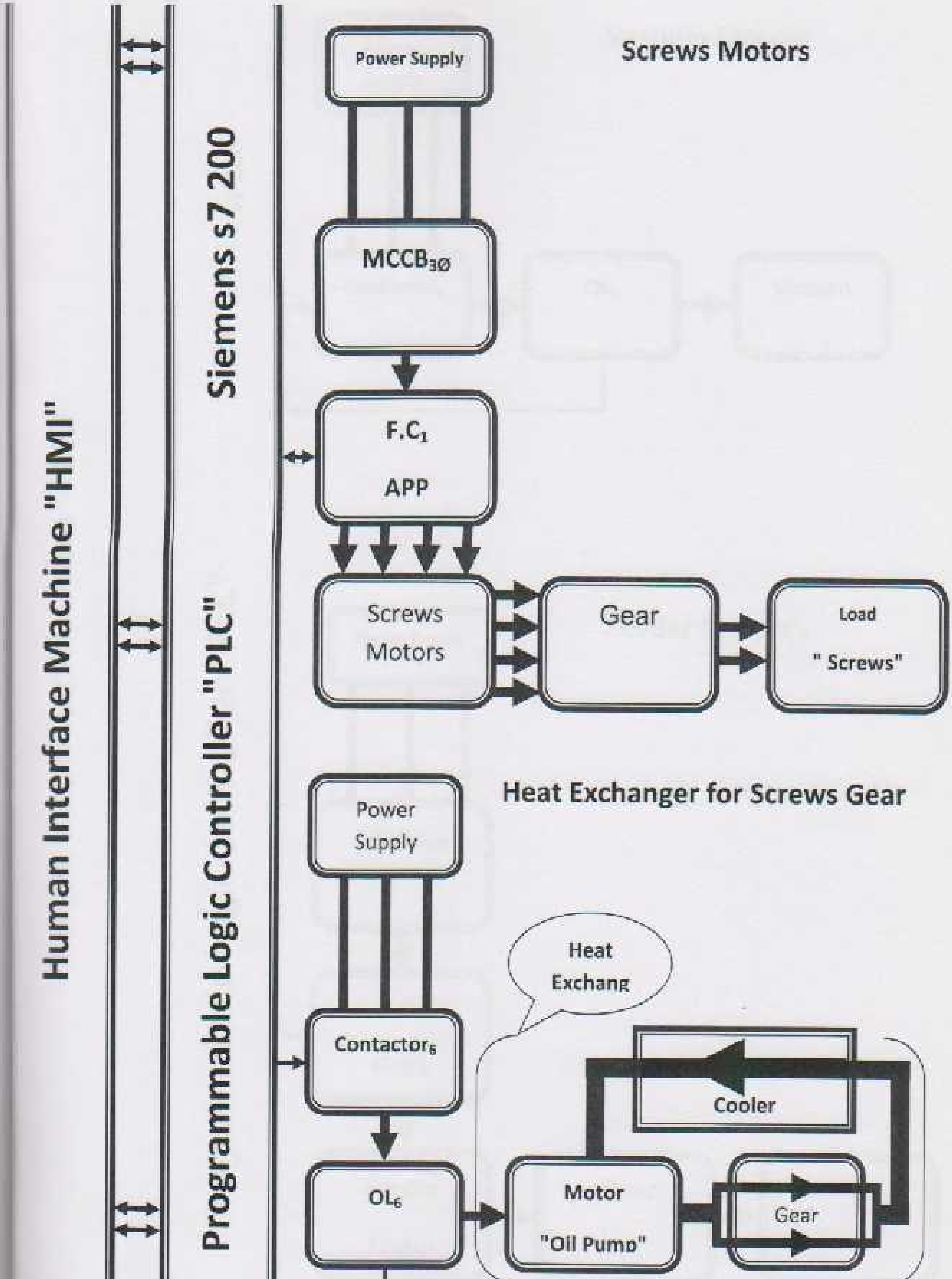
| Contents |
|---|
| **Appendix A: Block diagram** |
| **Appendix B: Flow chart** |
| **Appendix C: Designed circuits** |
| **Appendix D: PLC symbol table** |
| **Appendix E: PLC program** |

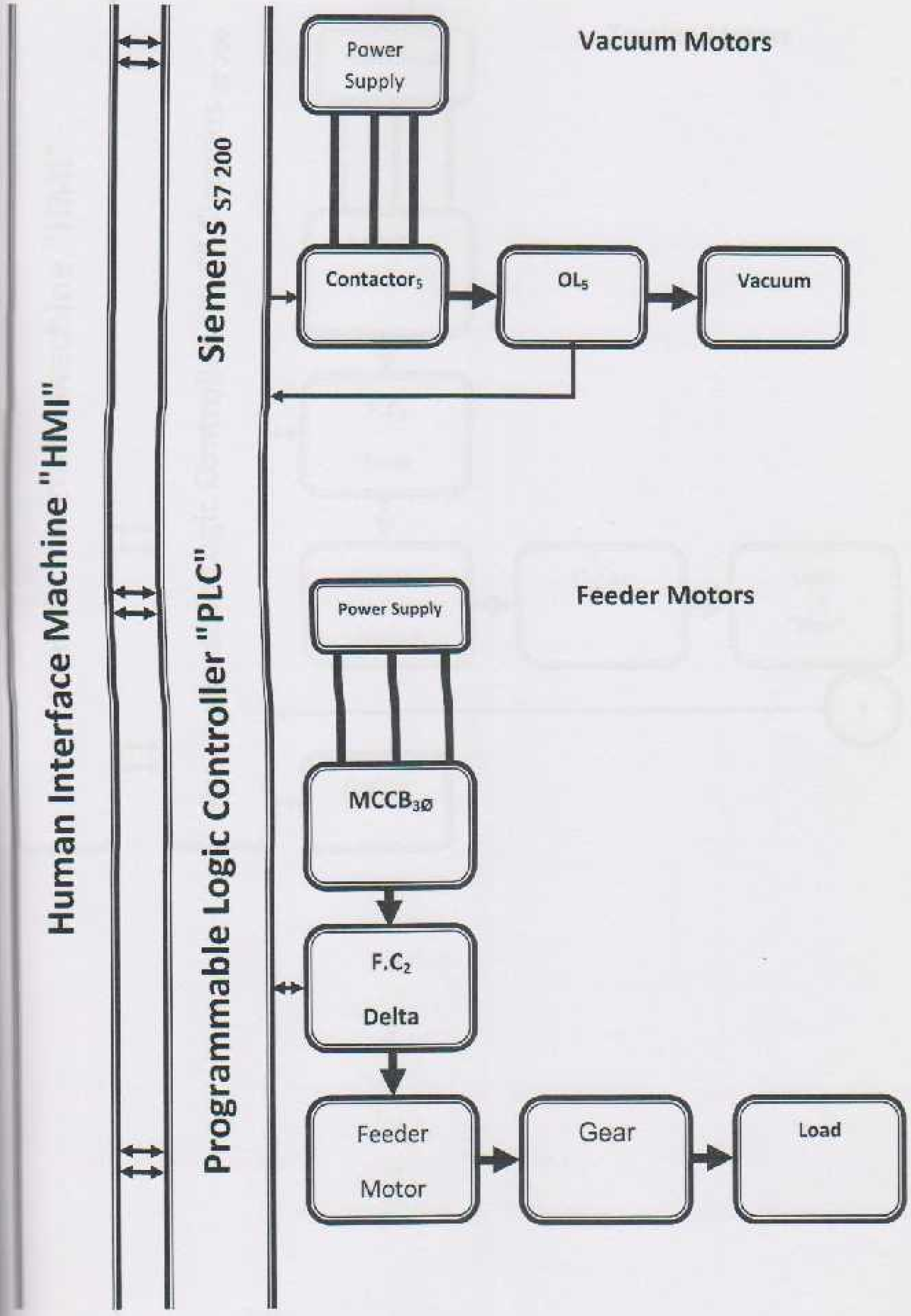
### *5.1: Block Diagram*



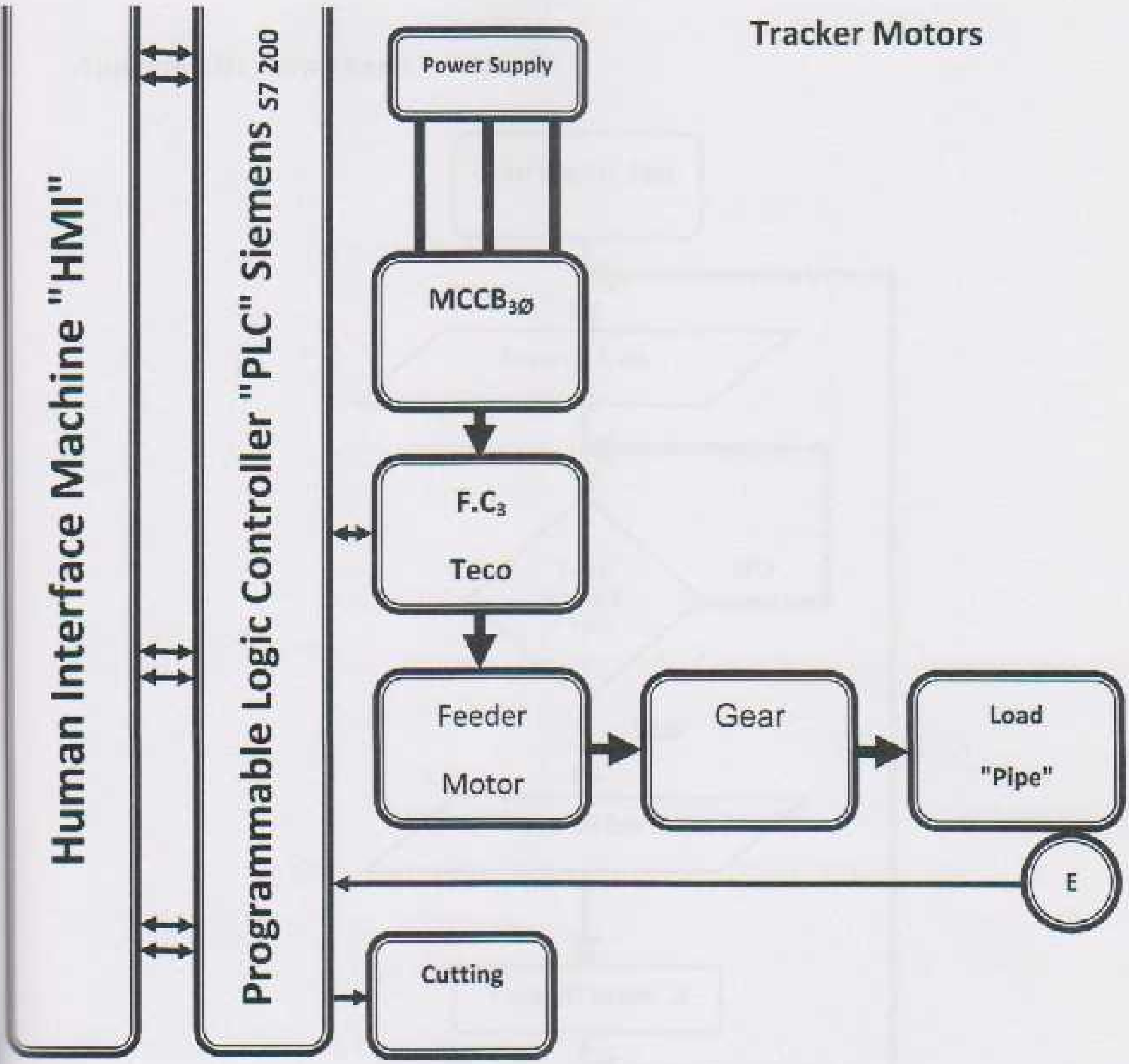

Human Interface Machine "HMI"
Programmable Logic Controller "PLC"
Siemens s7 200
Power Supply
Fuse
Solid State Relay5
Heater5
Thermocouple Sensor5
Power Supply
Fuse
Solid State
Heater12
Thermocouple Sensor12
Heat Exchanger for Haters
Power Supply
Heat Exchang
Contactor7
Cooler
OL7
Motor
"Water Pump"
Heaters


Human Interface Machine "HMI"
Programmable Logic Controller "PLC" Siemens s7 200
Fans Systems
Power Supply
Contactor₁
OL₁
Fan
Power Supply
Contactor₂
OL₂
Fan
Power Supply
Contactor₃
OL₃
Fan

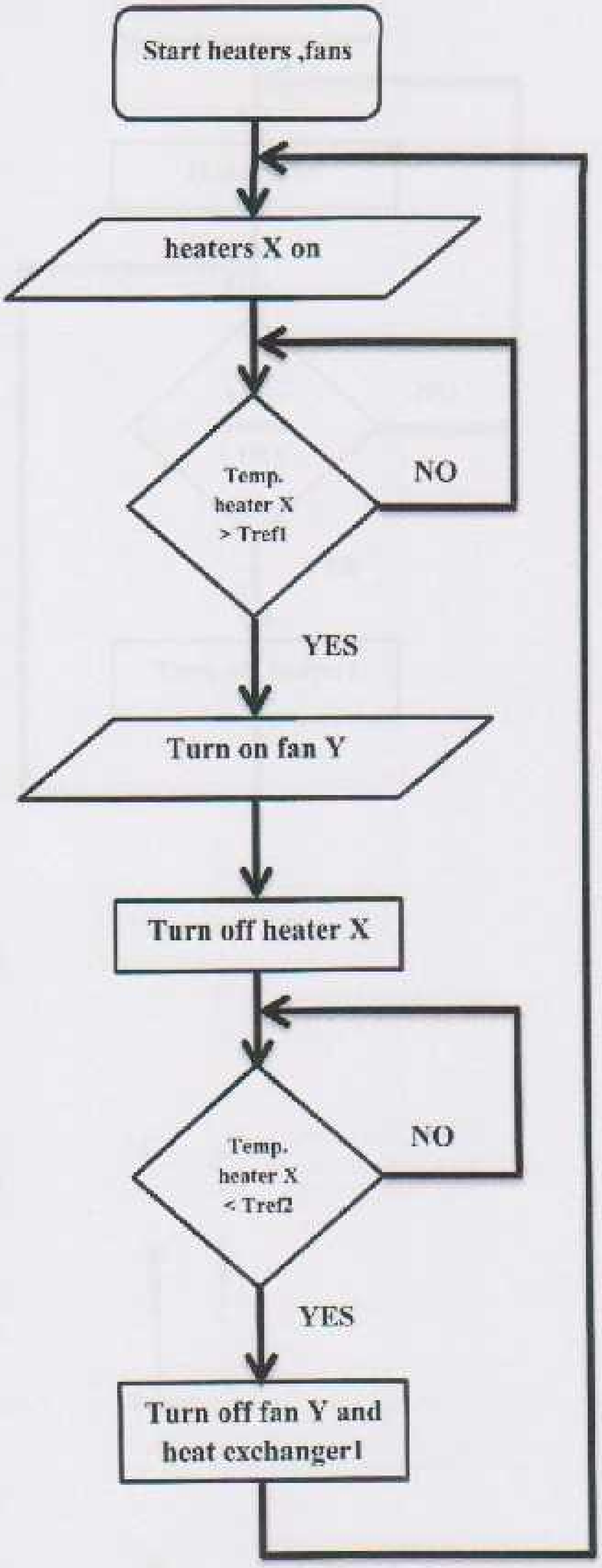

Human Interface Machine "HMI"
Programmable Logic Controller "PLC"
Siemens s7 200
Screws Motors
Power Supply
MCCB$_{3Ø}$
F.C$_1$
APP
Screws
Motors
Gear
Load
" Screws"
Heat Exchanger for Screws Gear
Power
Supply
Heat
Exchang
Contactor$_6$
Cooler
OL$_6$
Motor
"Oil Pump"
Gear

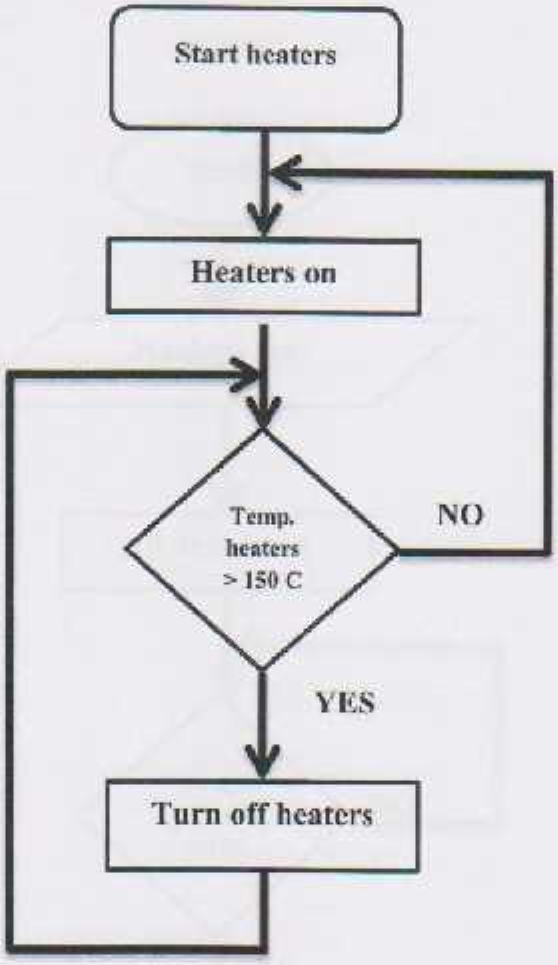

Human Interface Machine "HMI"
Programmable Logic Controller "PLC"
Siemens S7 200
Vacuum Motors
Power Supply
Contactor5
OL5
Vacuum
Feeder Motors
Power Supply
MCCB3ø
F.C2
Delta
Feeder Motor
Gear
Load

## Tracker Motors

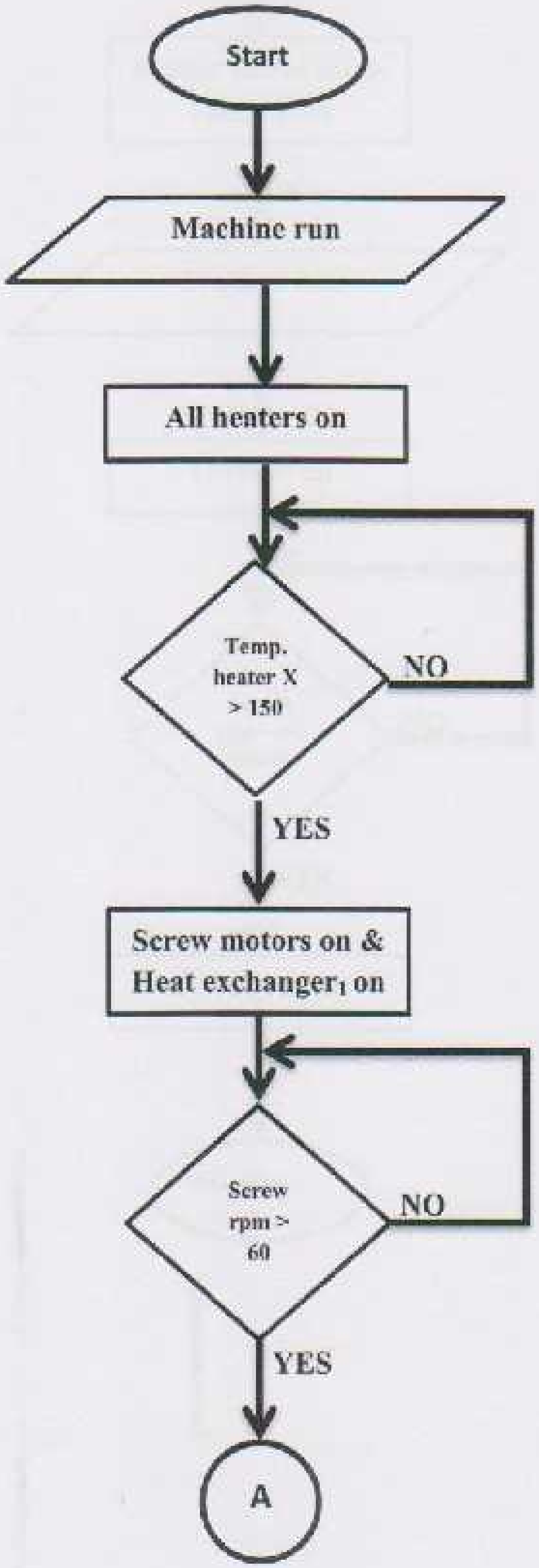


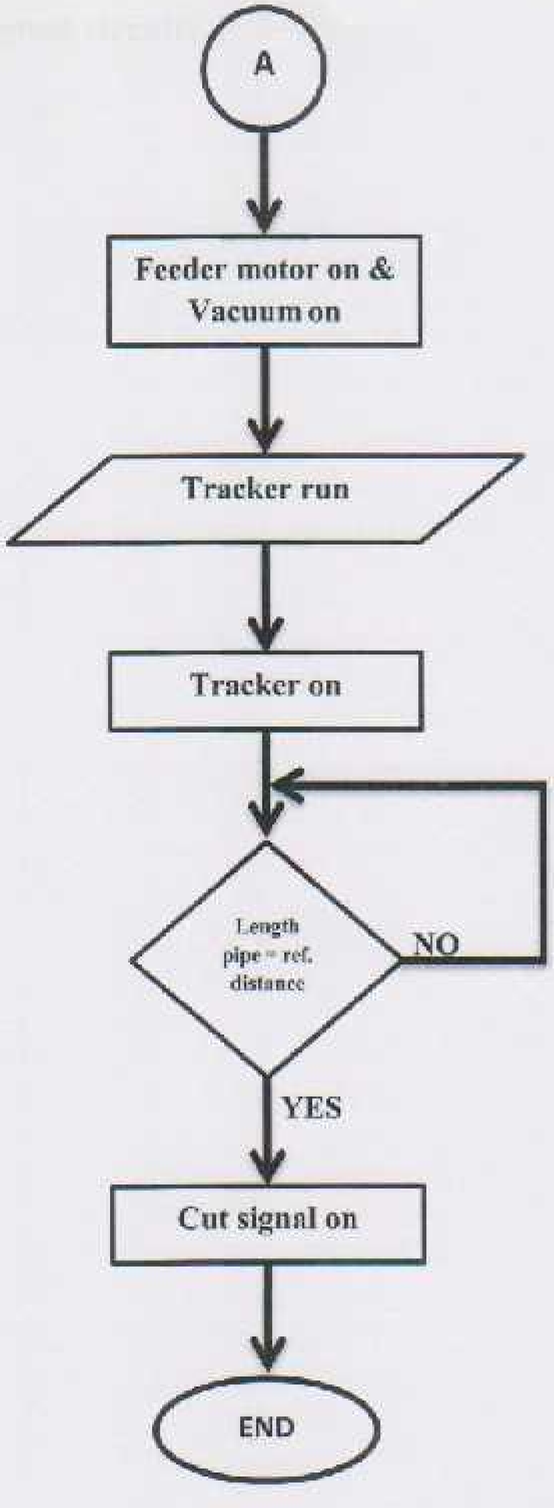
Appendix B: Flow charts



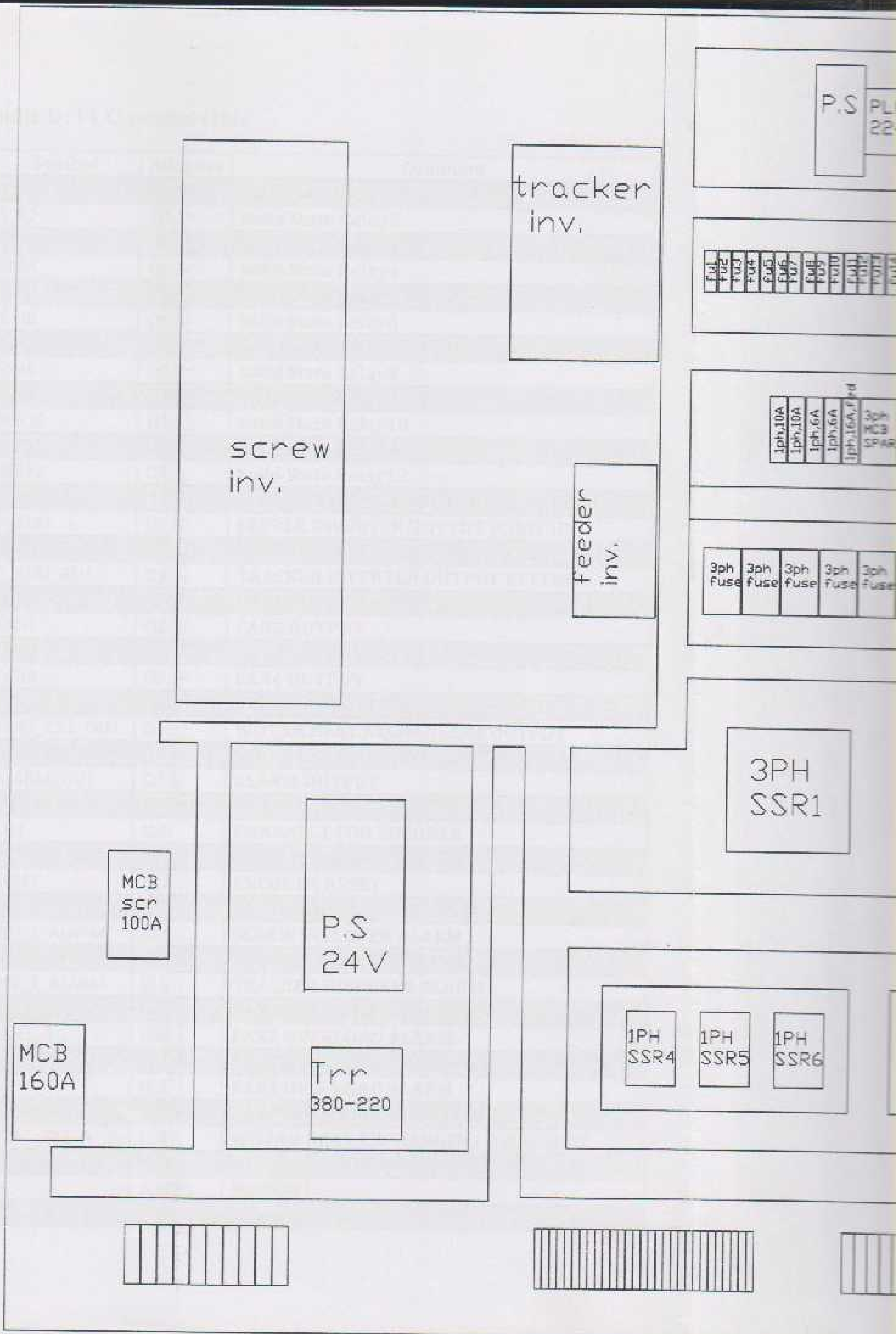

Start heaters
Heaters on
Temp.
heaters
> 150 C
NO
YES
Turn off heaters

## Appendix B: Flow charts

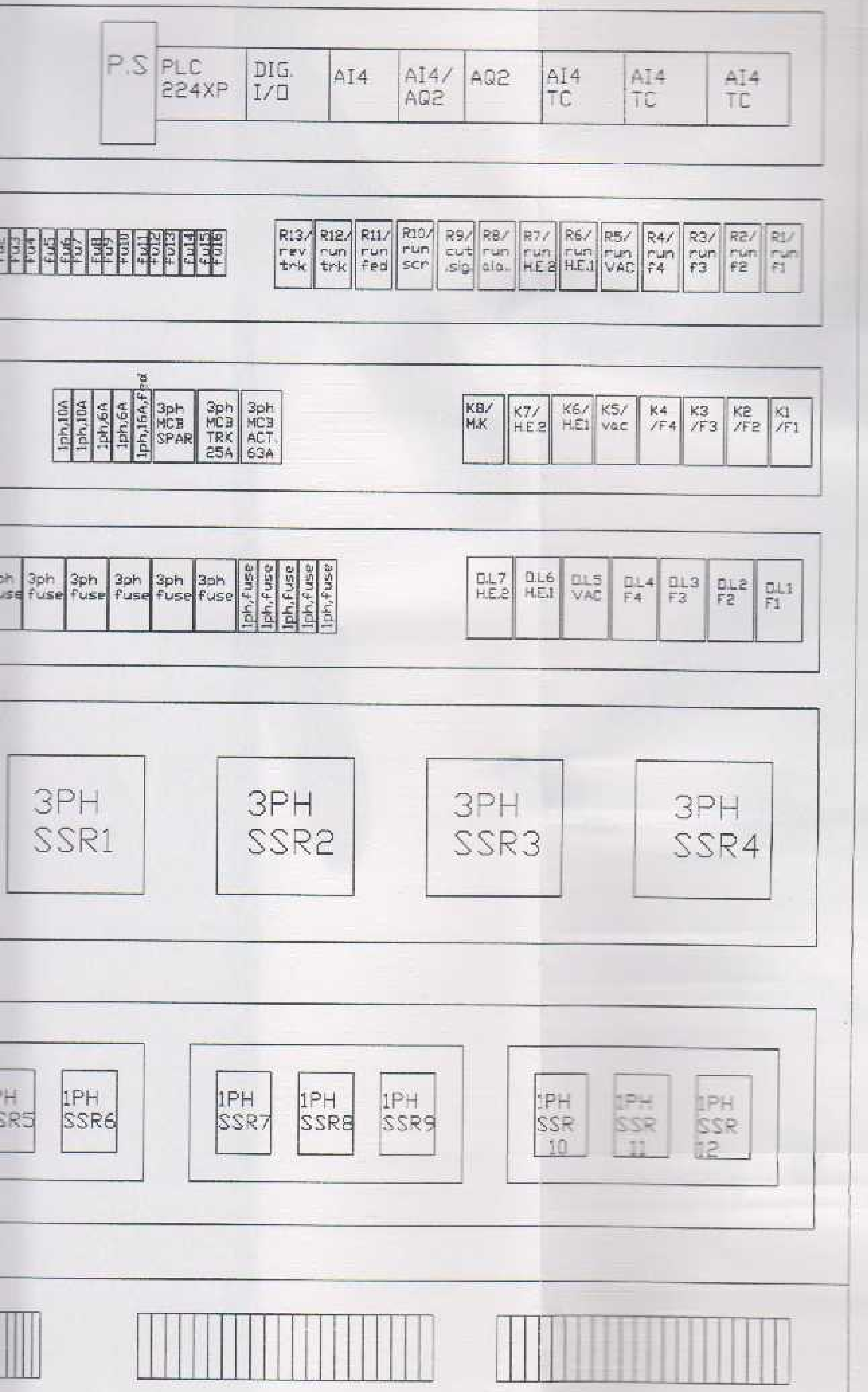



A
Feeder motor on &
Vacuum on
Tracker run
Tracker on
Length
pipe = ref.
distance
NO
YES
Cut signal on
END

## Appendix C: Designed circuits



P.S
tracker inv.
screw inv.
feeder inv.
3ph fuse
3ph fuse
3ph fuse
3ph fuse
3ph fuse
3PH SSR1
MCB scr 100A
P.S 24V
MCB 160A
Trr 380-220
1PH SSR4
1PH SSR5
1PH SSR6


P.S
PLC 224XP
DIG. I/O
AI4
AI4/ AQ2
AQ2
AI4 TC
AI4 TC
AI4 TC
R13/ rev trk
R12/ run trk
R11/ run fed
R10/ run scr
R9/ cut sig
R8/ run ala
R7/ run H.E.2
R6/ run H.E.1
R5/ run VAC
R4/ run F4
R3/ run F3
R2/ run F2
R1/ run F1
1ph,10A
1ph,10A
1ph,6A
1ph,6A
3ph MCB SPAR
3ph MCB TRK 25A
3ph MCB ACT. 63A
K8/ M.K
K7/ H.E.2
K6/ H.E.1
K5/ vac
K4 /F4
K3 /F3
K2 /F2
K1 /F1
3ph fuse
3ph fuse
3ph fuse
3ph fuse
3ph fuse
1ph,fuse
1ph,fuse
1ph,fuse
1ph,fuse
1ph,fuse
D.L7 H.E.2
D.L6 H.E.1
D.L5 VAC
D.L4 F4
D.L3 F3
D.L2 F2
D.L1 F1
3PH SSR1
3PH SSR2
3PH SSR3
3PH SSR4
1PH SSR6
1PH SSR7
1PH SSR8
1PH SSR9
1PH SSR 10
1PH SSR 11
1PH SSR 12

## Appendix D: PLC symbol table

| No | Symbol | Address | Comment |
|---|---|---|---|
| 1 | SSR1 | Q0.0 | Solid State Relay1 |
| 2 | SSR2 | Q0.1 | Solid State Relay2 |
| 3 | SSR3 | Q0.2 | Solid State Relay3 |
| 4 | SSR4 | Q0.3 | Solid State Relay4 |
| 5 | SSR5 | Q0.4 | Solid State Relay5 |
| 6 | SSR6 | Q0.5 | Solid State Relay6 |
| 7 | SSR7 | Q0.6 | Solid State Relay7 |
| 8 | SSR8 | Q0.7 | Solid State Relay8 |
| 9 | SSR9 | Q1.0 | Solid State Relay9 |
| 10 | SSR10 | Q1.1 | Solid State Relay10 |
| 11 | SSR11 | Q2.0 | Solid State Relay11 |
| 12 | SSR12 | Q2.1 | Solid State Relay12 |
| 13 | S_RUN | Q2.2 | SCREW INVERTER OUTPUT FORWARD |
| 14 | F_RUN | Q2.3 | FEEDER INVERTER OUTPUT FORWARD |
| 15 | T_RUN | Q2.4 | TRACKER INVERTER OUTPUT FORWARD |
| 16 | T_RUN_REV | Q2.5 | TRACKER INVERTER OUTPUT REVERSE |
| 17 | FAN1 | Q2.6 | FAN1 OUTPUT |
| 18 | FAN2 | Q2.7 | FAN2 OUTPUT |
| 19 | FAN3 | Q3.0 | FAN3 OUTPUT |
| 20 | FAN4 | Q3.1 | FAN4 OUTPUT |
| 21 | VAC_OUT | Q3.2 | VACUUM OUTPUT |
| 22 | HEAT_EX1_OUT | Q3.3 | WOTAR HEAT EXCHANGER1 OUTPUT |
| 23 | HEAT_EX2_OUT | Q3.4 | OIL HEAT EXCHANGER2 OUTPUT |
| 24 | ALARM_OUT | Q3.5 | ALARM OUTPUT |
| 25 | CUT_OUT | Q3.6 | CUT OUTPUT |
| 26 | CH1 | I0.0 | CHANNEL1 FOR ENCODER |
| 27 | CH2 | I0.1 | CHANNEL2 FOR ENCODER |
| 28 | RESET | I0.2 | ENCODER RESET |
| 29 | EM | I0.3 | EMERGENCE |
| 30 | INV_S_ALARM | I0.4 | SCREW INVERTER ALARM |
| 31 | INV_F_ALARM | I0.5 | FEEDER INVERTER ALARM |
| 32 | INV_T_ALARM | I0.6 | TRACKER INVERTER ALARM |
| 33 | FAN1_A | I0.7 | FAN1 OVERLOAD ALARM |
| 34 | FAN2_A | I1.0 | FAN2 OVERLOAD ALARM |
| 35 | FAN3_A | I1.1 | FAN3 OVERLOAD ALARM |
| 36 | FAN4_A | I1.2 | FAN3 OVERLOAD ALARM |
| 37 | VACUUM_A | I1.3 | VACUUM OVERLODE OVERLOAD ALARM |
| 38 | HEAT_EX1_A | I1.4 | WOTAR HEAT EXCHANGER1 OVERLOAD |
| 39 | HEAT_EX2_A | I1.5 | OIL HEAT EXCHANGER2 OVERLOAD |
| 40 | S1 | AIW20 | SENSOR1 |
| 41 | S2 | AIW22 | SENSOR2 |

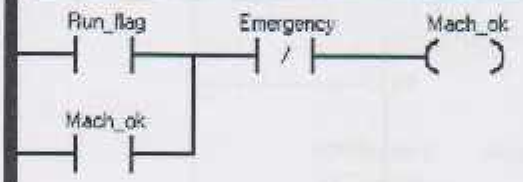
| No | Symbol | Address | Comment |
|---|---|---|---|
| 42 | S3 | AIW24 | SENSOR3 |
| 43 | S4 | AIW26 | SENSOR4 |
| 44 | S5 | AIW28 | SENSOR5 |
| 45 | S6 | AIW30 | SENSOR6 |
| 46 | S7 | AIW32 | SENSOR7 |
| 47 | S8 | AIW34 | SENSOR8 |
| 48 | S9 | AIW36 | SENSOR9 |
| 49 | S10 | AIW38 | SENSOR10 |
| 50 | S11 | AIW40 | SENSOR11 |
| 51 | S12 | AIW42 | SENSOR12 |
| 52 | SPEED_CON1 | AQW0 | SCREW INVERTER_SPEED CONTROL |
| 53 | SPEED_CON2 | AQW10 | FEEDER INVERTER_SPEED CONTROL |
| 54 | SPEED_CON3 | AQW8 | TRACKER INVERTER_SPEED CONTROL |
| 56 | SPEED_FEED1 | AIW4 | SCREW INVERTER_SPEED FEEDBACK |
| 57 | SPEED_FEED2 | AIW6 | FEEDER INVERTER_SPEED FEEDBACK |
| 58 | SPEED_FEED3 | ALW8 | TRACKER INVERTER_SPEED FEEDBACK |
| 59 | CURRENT_FEED | ALW12 | SCREW INVERTER_ CURRENT FEEDBACK |
| 60 | H1_RUN | M0.0 | HEATER1 ON FROM HMI |
| 61 | H2_RUN | M0.1 | HEATER2 ON FROM HMI |
| 62 | H3_RUN | M0.2 | HEATER3 ON FROM HMI |
| 63 | H4_RUN | M0.3 | HEATER4 ON FROM HMI |
| 64 | H5_RUN | M0.4 | HEATER5 ON FROM HMI |
| 65 | H6_RUN | M0.5 | HEATER6 ON FROM HMI |
| 66 | H7_RUN | M0.6 | HEATER7 ON FROM HMI |
| 67 | H8_RUN | M0.7 | HEATER8 ON FROM HMI |
| 68 | H9_RUN | M1.0 | HEATER9 ON FROM HMI |
| 69 | H10_RUN | M1.1 | HEATER10 ON FROM HMI |
| 70 | H11_RUN | M2.0 | HEATER11 ON FROM HMI |
| 71 | H12_RUN | M2.1 | HEATER12 ON FROM HMI |
| 72 | S_RUN | M2.2 | SCREW INVERTER RUN FROM HMI |
| 73 | F_RUN | M2.3 | FEEDER INVERTER RUN FROM HMI |
| 74 | T_RUN | M2.4 | TRACKER INVERTER RUN FROM HMI |
| 75 | T_REV | M2.5 | TRACKER INVERTER REVERSE FROM HMI |
| 76 | FAN1_RUN | M2.6 | FAN1 RUN FROM HMI |
| 77 | FAN2_RUN | M2.7 | FAN2 RUN FROM HMI |
| 78 | FAN3_RUN | M3.0 | FAN3 RUN FROM HMI |
| 79 | FAN4_RUN | M3.1 | FAN4 RUN FROM HMI |
| 80 | VAC_RUN | M3.2 | VACUUM RUN FROM HMI |
| 81 | HEAT_EX1 | M3.3 | WOTAR HEAT EXCHANGER1 RUN HMI |
| 82 | HEAT_EX2 | M3.4 | OIL HEAT EXCHANGER2 RUN HMI |
| 83 | RUN_FLAG | M4.0 | RUN ALL MACHINE FROM HMI |
| 84 | MAC_OK | M4.1 | MACHINE BEGIN IN WORK |
| 85 | EM_S | M6.1 | EMERGENCE SOFTWARE FROM HMI |

| No | Symbol | Address | Comment |
|---|---|---|---|
| 86 | S1_REF | VD4 | SENSOR1 REFERENC VALUE FROM HMI |
| 87 | S2_REF | VD12 | SENSOR2 REFERENC VALUE FROM HMI |
| 88 | S3_REF | VD20 | SENSOR3 REFERENC VALUE FROM HMI |
| 89 | S4_REF | VD28 | SENSOR4 REFERENC VALUE FROM HMI |
| 90 | S5_REF | VD36 | SENSOR5 REFERENC VALUE FROM HMI |
| 91 | S6_REF | VD44 | SENSOR6 REFERENC VALUE FROM HMI |
| 92 | S7_REF | VD52 | SENSOR7 REFERENC VALUE FROM HMI |
| 93 | S8_REF | VD60 | SENSOR8 REFERENC VALUE FROM HMI |
| 94 | S9_REF | VD68 | SENSOR9 REFERENC VALUE FROM HMI |
| 95 | S10_REF | VD76 | SENSOR10 REFERENC VALUE FROM HMI |
| 96 | S11_REF | VD84 | SENSOR11 REFERENC VALUE FROM HMI |
| 97 | S12_REF | VD92 | SENSOR12 REFERENC VALUE FROM HMI |
| 98 | S1_ACT | VD0 | SENSOR1 ACTUAL VALUE TO HMI |
| 99 | S2_ACT | VD8 | SENSOR2 ACTUAL VALUE TO HMI |
| 100 | S3_ACT | VD16 | SENSOR3 ACTUAL VALUE TO HMI |
| 101 | S4_ACT | VD24 | SENSOR4 ACTUAL VALUE TO HMI |
| 102 | S5_ACT | VD32 | SENSOR5 ACTUAL VALUE TO HMI |
| 103 | S6_ACT | VD40 | SENSOR6 ACTUAL VALUE TO HMI |
| 104 | S7_ACT | VD48 | SENSOR7 ACTUAL VALUE TO HMI |
| 105 | S8_ACT | VD56 | SENSOR8 ACTUAL VALUE TO HMI |
| 106 | S9_ACT | VD64 | SENSOR9 ACTUAL VALUE TO HMI |
| 107 | S10_ACT | VD72 | SENSOR10 ACTUAL VALUE TO HMI |
| 108 | S11_ACT | VD80 | SENSOR11 ACTUAL VALUE TO HMI |
| 109 | S12_ACT | VD88 | SENSOR12 ACTUAL VALUE TO HMI |
| 110 | S_SPEED_REF | VD100 | SCREW INVERTER_ REFERENSE FROM HMI |
| 111 | F_SPEED_REF | VD104 | FEEDER INVERTER_ REFERENSE FROM HMI |
| 112 | T_SPEED_REF | VD108 | TRACKER INVERTER_ REFERENSE FROM HMI |
| 113 | S_SPEED_FED | VD112 | SCREW INVERTER_ FEEDBACK TO HMI |
| 114 | F_SPEED_FED | VD116 | FEEDER INVERTER_ FEEDBACK TO HMI |
| 115 | T_SPEED_FED | VD120 | TRACKER INVERTER_ FEEDBACK TO HMI |
| 116 | S_CUR_FED | VD124 | SCREW INVERTER_ FEEDBACK TO HMI |
| 117 | ENC_REF | VD128 | ENCODER REFERENSE VALUE FROM HMI |
| 118 | ENC_ACT | VD132 | ENCODER ACTUAL VALUE TO HMI |

# Appendix E: PLC program

**Network 1** Network Title

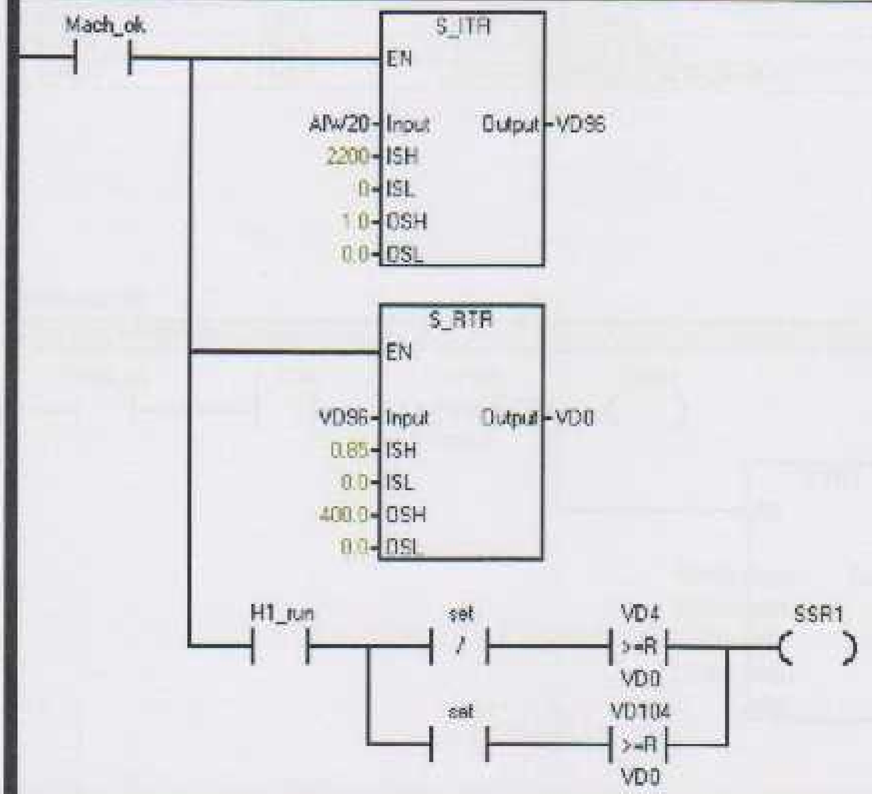
STARTING




| Symbol | Address | Comment |
|---|---|---|
| Emergency | I0.3 | emergency |
| Mach_ok | M4.1 | machine begin in work |
| Run_flag | M4.0 | run all machine FROM HMI |

**Network 2** Network Title

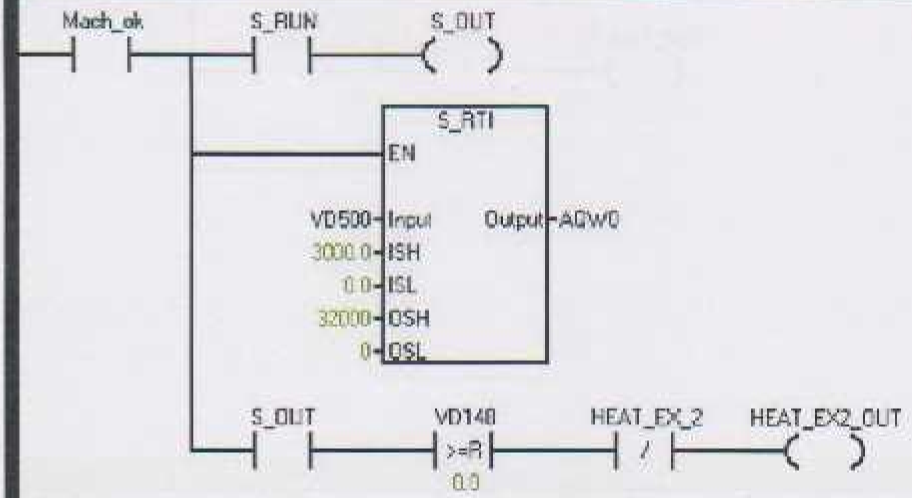
HEATER 1 CONTROL




| Symbol | Address | Comment |
|---|---|---|
| H1_run | M0.0 | HEATER1 ON FROM HMI |
| Mach_ok | M4.1 | machine begin in work |
| set | M4.2 | set of |
| SSR1 | Q0.0 | SOLID STATE RELAY1 |

**Network 15**

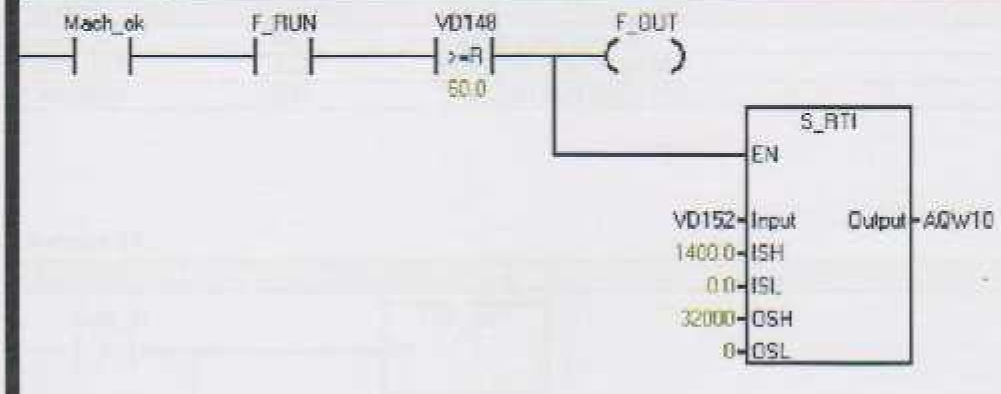
SCREW INVERTER




| Symbol | Address | Comment |
|---|---|---|
| HEAT_EX2_OUT | Q3.4 | HEAT EXCHANGER2 FOR GEAR |
| HEAT_EX_2 | I1.5 | HEAT EXCHANGER FOR GEAR OVERLOAD |
| Mach_ok | M4.1 | machine begin in work |
| S_OUT | Q2.2 | SCREW INVERTER RUN |
| S_RUN | M2.3 | SCREW INVERTER RUN FROM HMI |

**Network 16**

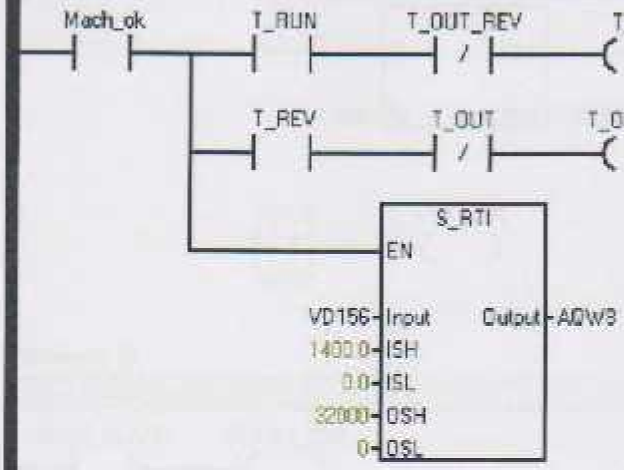
FEEDER INVERTER




| Symbol | Address | Comment |
|---|---|---|
| F_OUT | Q2.3 | FEEDER INVERTER RUN |
| F_RUN | M2.2 | FEEDER INVERTER RUN FROM HMI |
| Mach_ok | M4.1 | machine begin in work |

**Network 17**

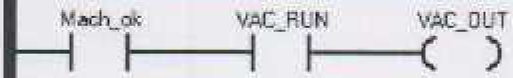
TRACKER INVERTER




| Symbol | Address | Comment |
|---|---|---|
| Mach_ok | M4.1 | machine begin in work |
| T_OUT | Q2.4 | TRACKER INVERTER RUN FOREWARD |
| T_OUT_REV | Q2.5 | TRACKER INVERTER REVERSE |
| T_REV | M2.5 | TRACKER INVERTER REVERSE FROM HMI |
| T_RUN | M2.4 | TRACKER INVERTER RUN AND FOREWARD FROM HMI |

**Network 18**

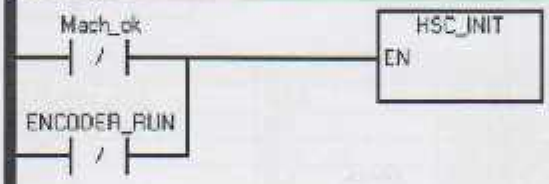
VACUUM




| Symbol | Address | Comment |
|---|---|---|
| Mach_ok | M4.1 | machine begin in work |
| VAC_OUT | Q3.2 | VACUUM RUN FROM HMI |
| VAC_RUN | M3.2 | VACUUM RUN FROM HMI |

**Network 19**

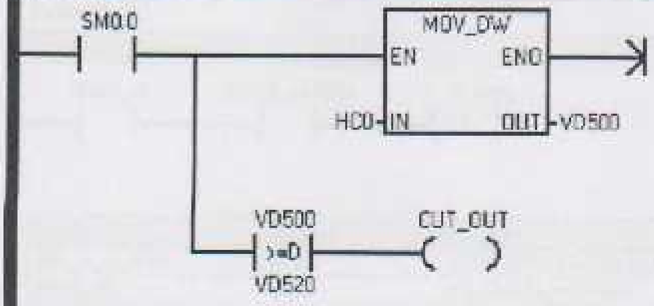
CUTTING




| Symbol | Address | Comment |
|---|---|---|
| ENCODER_RUN | M4.3 | RUN ENCODER |
| Mach_ok | M4.1 | machine begin in work |

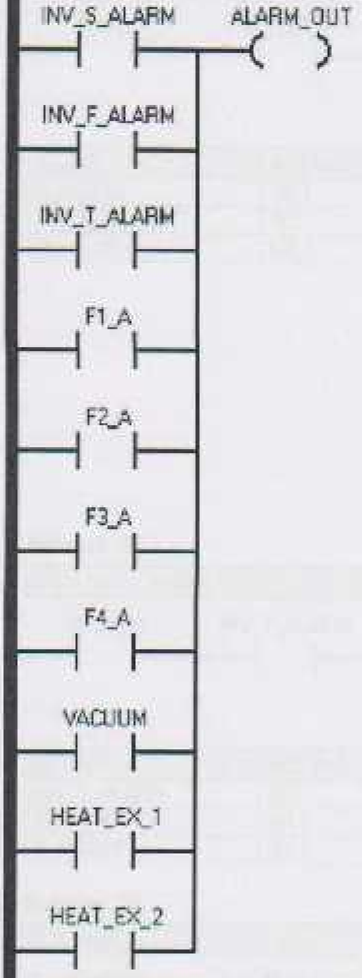
**Network 20**

CUTTING




**Network 21**

input alarm .




| Symbol | Address | Comment |
|---|---|---|
| ALARM_OUT | Q3.5 | ALARM OUT |
| F1_A | I0.7 | FAN1 OVERLOAD |
| F2_A | I1.0 | FAN2 OVERLOAD |
| F3_A | I1.1 | FAN3 OVERLOAD |
| F4_A | I1.2 | FAN4 OVERLOAD |
| HEAT_EX_1 | I1.4 | HEAT EXCHANGER FOR HEATERS OVERLOAD |
| HEAT_EX_2 | I1.5 | HEAT EXCHANGER FOR GEAR OVERLOAD |
| INV_F_ALARM | I0.5 | FEEDER INVERTER ALARM |
| INV_S_ALARM | I0.4 | SCREW INVERTER ALARM |
| INV_T_ALARM | I0.6 | TRACKER INVERTER ALARM |
| VACUUM | I1.3 | VACUUM OVERLOAD |

**Network 22**

alarm screw inverter.


| Symbol | Address | Comment |
|---|---|---|
| INV_S_ALARM | I0.4 | SCREW INVERTER ALARM |
| Mach_ok | M4.1 | machine begin in work |
| S_ALARM | M5.0 | HMI OUTPUT |

**Network 23**

alarm feeder inverter


| Symbol | Address | Comment |
|---|---|---|
| F_ALARM | M5.1 | HMI OUTPUT |
| INV_F_ALARM | I0.5 | FEEDER INVERTER ALARM |
| Mach_ok | M4.1 | machine begin in work |

**Network 24**

alarm tracker inverter


| Symbol | Address | Comment |
|---|---|---|
| INV_T_ALARM | I0.6 | TRACKER INVERTER ALARM |
| Mach_ok | M4.1 | machine begin in work |
| T_ALARM | M5.2 | HMI OUTPUT |

**Network 25**

alarm fan1


| Symbol | Address | Comment |
|---|---|---|
| F1_A | I0.7 | FAN1 OVERLOAD |
| FAN1_ALARM | M5.3 | HMI OUTPUT |
| Mach_ok | M4.1 | machine begin in work |

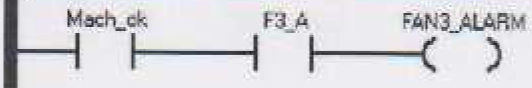
**Network 26**

alarm fan2


| Symbol | Address | Comment |
|---|---|---|
| F2_A | I1.0 | FAN2 OVERLOAD |
| FAN2_ALARM | M5.4 | HMI OUTPUT |
| Mach_ok | M4.1 | machine begin in work |

**Network 27**

alarm fan3




| Symbol | Address | Comment |
|---|---|---|
| F3_A | I1.1 | FAN3 OVERLOAD |
| FAN3_ALARM | M5.5 | HMI OUTPUT |
| Mach_ok | M4.1 | machine begin in work |

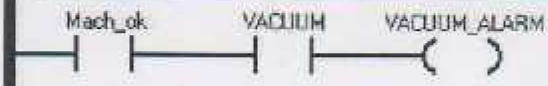
**Network 28**

alarm fan4


| Symbol | Address | Comment |
|---|---|---|
| F4_A | I1.2 | FAN4 OVERLOAD |
| FAN4_ALARM | M5.6 | HMI OUTPUT |
| Mach_ok | M4.1 | machine begin in work |

**Network 29**

alarm vacuum




| Symbol | Address | Comment |
|---|---|---|
| Mach_ok | M4.1 | machine begin in work |
| VACUUM | I1.3 | VACUUM OVERLOAD |
| VACUUM_ALARM | M5.7 | HMI OUTPUT |

**Network 30**

heat ex 1 alarm


| Symbol | Address | Comment |
|---|---|---|
| HEAT_EX1_A | M6.0 | HMI OUTPUT |
| HEAT_EX_1 | I1.4 | HEAT EXCHANGER FOR HEATERS OVERLOAD |
| Mach_ok | M4.1 | machine begin in work |

**Network 31**

heat ex 2 alarm


| Symbol | Address | Comment |
|---|---|---|
| HEAT_EX2_A | M6.1 | HMI OUTPUT |
| HEAT_EX_2 | I1.5 | HEAT EXCHANGER FOR GEAR OVERLOAD |
| Mach_ok | M4.1 | machine begin in work |

**Network 32**

Manual run fan1


| Symbol | Address | Comment |
|---|---|---|
| F1_A | I0.7 | FAN1 OVERLOAD |
| FAN1 | Q2.6 | FAN1 RUN |
| FAN1_RUN | M2.6 | HMI FAN 1 RUN |

**Network 33**

Manual run fan2


| Symbol | Address | Comment |
|---|---|---|
| F2_A | I1.0 | FAN2 OVERLOAD |
| FAN2 | Q2.7 | FAN2 RUN |
| FAN2_RUN | M2.7 | HMI FAN 2 RUN |

**Network 34**

Manual run fan3


| Symbol | Address | Comment |
|---|---|---|
| F3_A | I1.1 | FAN3 OVERLOAD |
| FAN3 | Q3.0 | FAN3 RUN |
| FAN3_RUN | M3.0 | HMI FAN 3 RUN |

**Network 35**

Manual run fan4


| Symbol | Address | Comment |
|---|---|---|
| F4_A | I1.2 | FAN4 OVERLOAD |
| FAN4 | Q3.1 | FAN4 RUN |
| FAN4_RUN | M3.1 | HMI FAN 4 RUN |

**Network 36**

Manual run heat exchanger 1

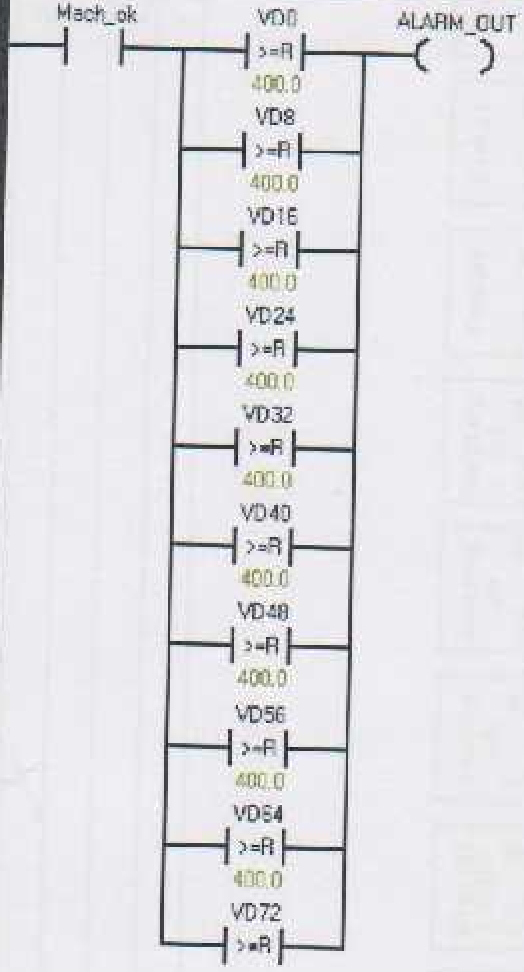

| Symbol | Address | Comment |
|---|---|---|
| HEAT_EX1 | M3.3 | HEAT EXCHANGER1 FOR HEATERS FROM HMI |
| HEAT_EX1_OUT | Q3.3 | HEAT EXCHANGER1 FOR HEATERS |
| HEAT_EX_1 | I1.4 | HEAT EXCHANGER FOR HEATERS OVERLOAD |

**Network 37**

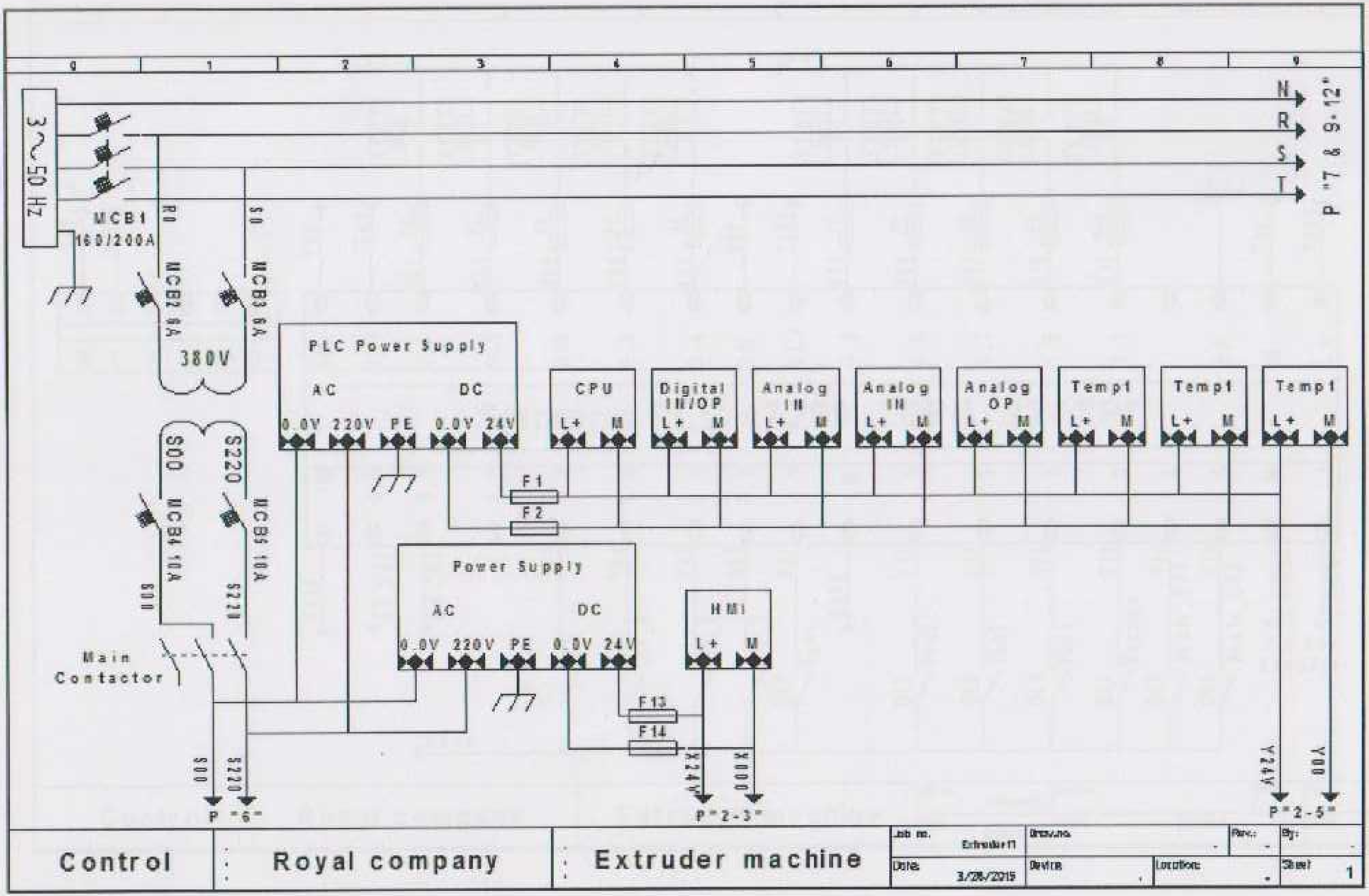
Manual run heat exchanger 2


| Symbol | Address | Comment |
|---|---|---|
| HEAT_EX2 | M3.4 | HEAT EXCHANGER2 FOR GEAR FROM HMI |
| HEAT_EX2_OUT | Q3.4 | HEAT EXCHANGER2 FOR GEAR |
| HEAT_EX_2 | I1.5 | HEAT EXCHANGER FOR GEAR OVERLOAD |

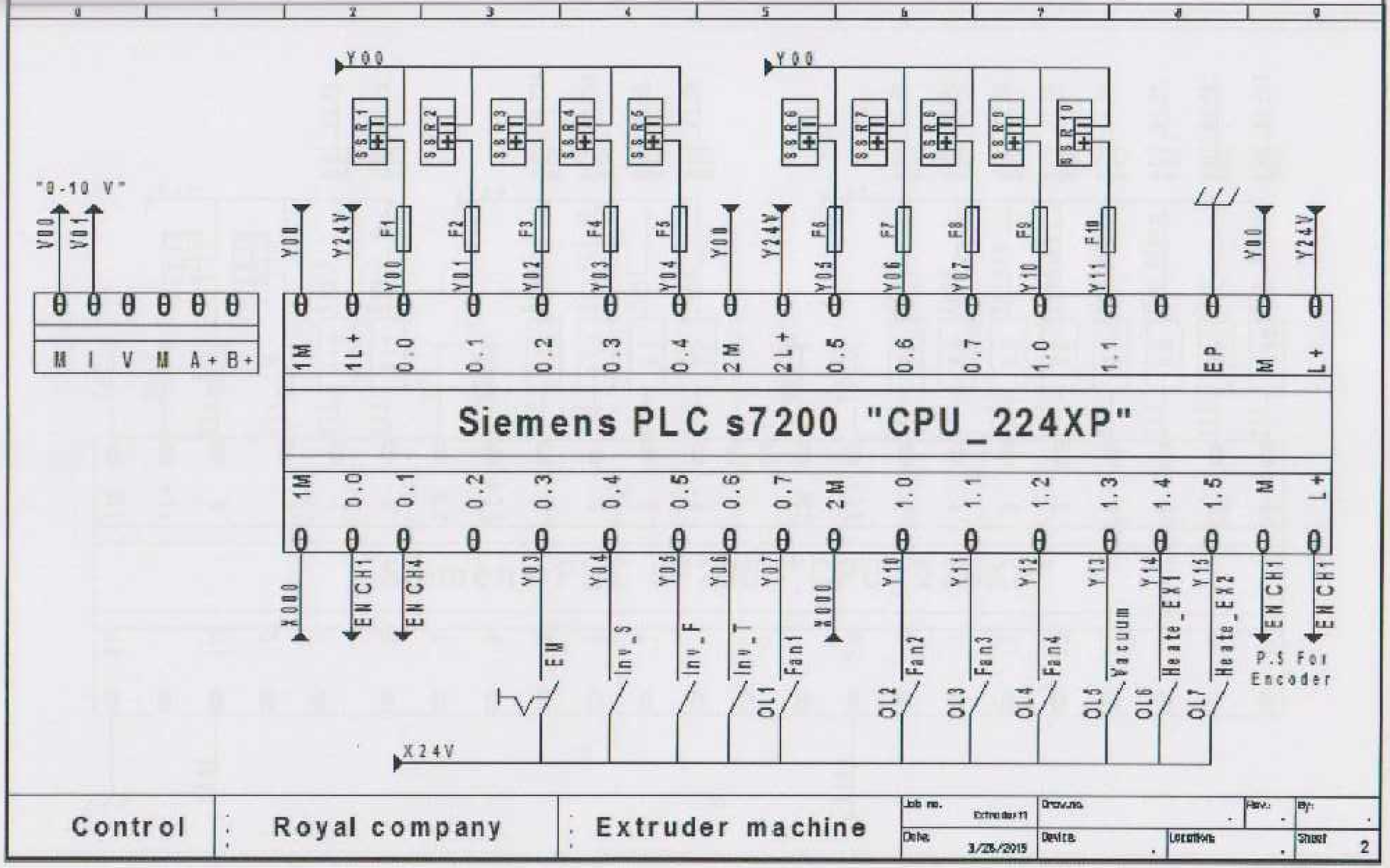
**Network 38**

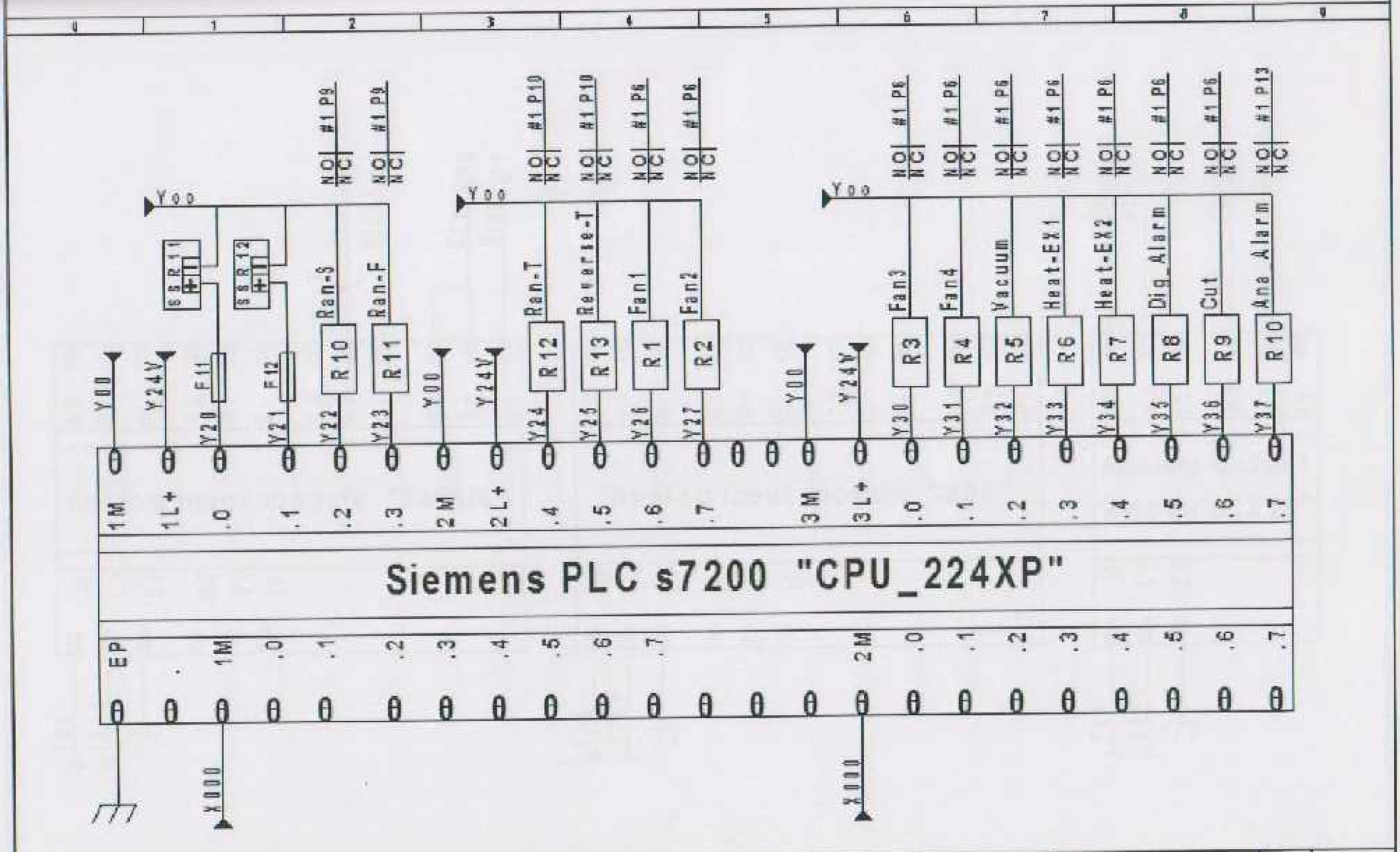



| Symbol | Address | Comment |
|---|---|---|
| ALARM_OUT | Q3.5 | ALARM OUT |
| Mach_ok | M4.1 | machine begin in work |

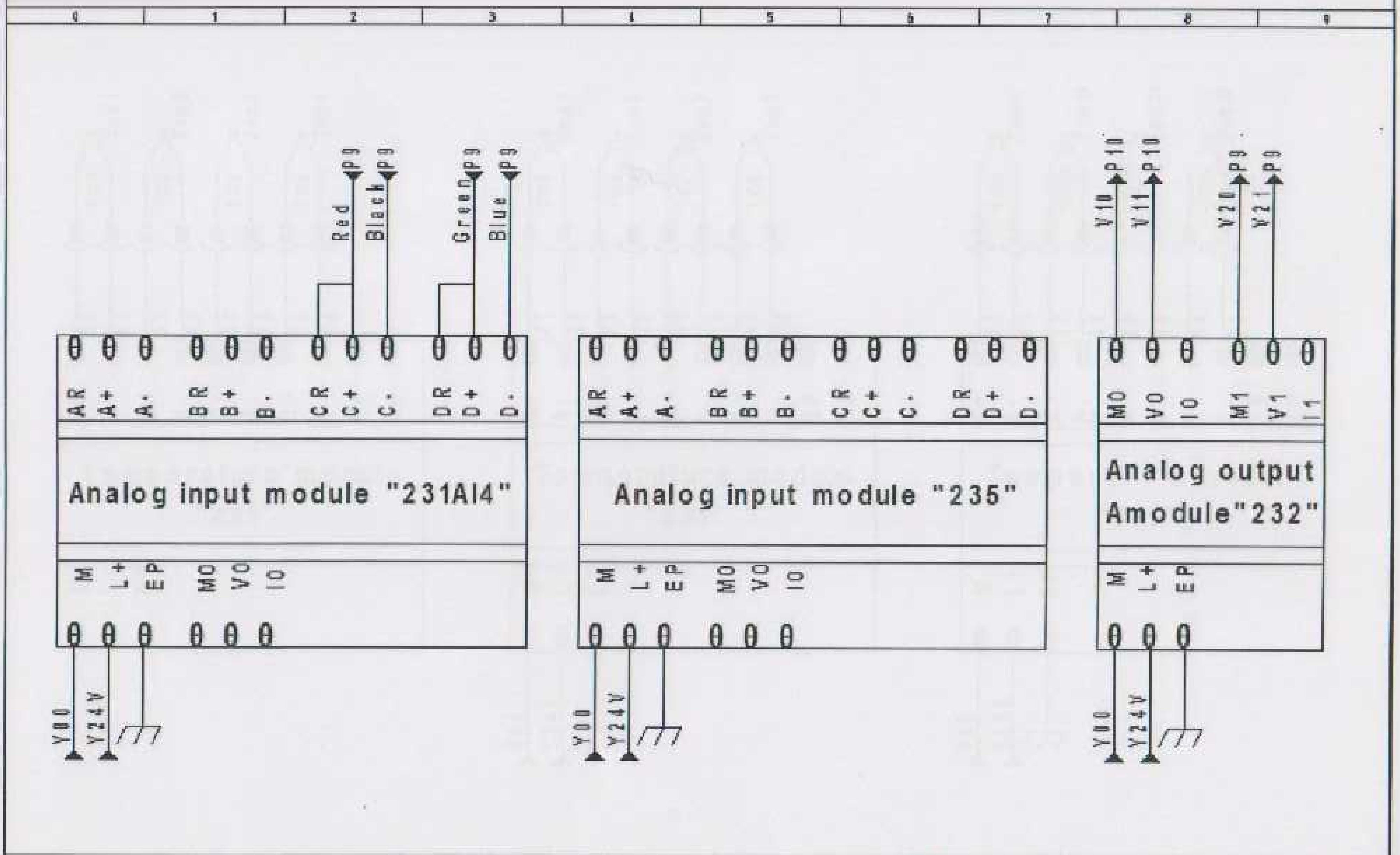


3~50 Hz
MCB1 160/200A
R0
S0
MCB2 6A
MCB3 6A
380V
S00
S220
MCB4 10A
MCB5 10A
Main Contactor
N
R
S
T
P "7 & 9-12"
PLC Power Supply
AC
DC
0.0V 220V PE 0.0V 24V
F1
F2
CPU
Digital IN/OP
Analog IN
Analog IN
Analog OP
Temp1
Temp1
Temp1
L+ M
Power Supply
HMI
F13
F14
X24V
X000
P "2-3"
Y24V
Y00
P "2-5"
P "6"
Control
Royal company
Extruder machine
Job no. Extruder1
Date 3/28/2019
Sheet 1

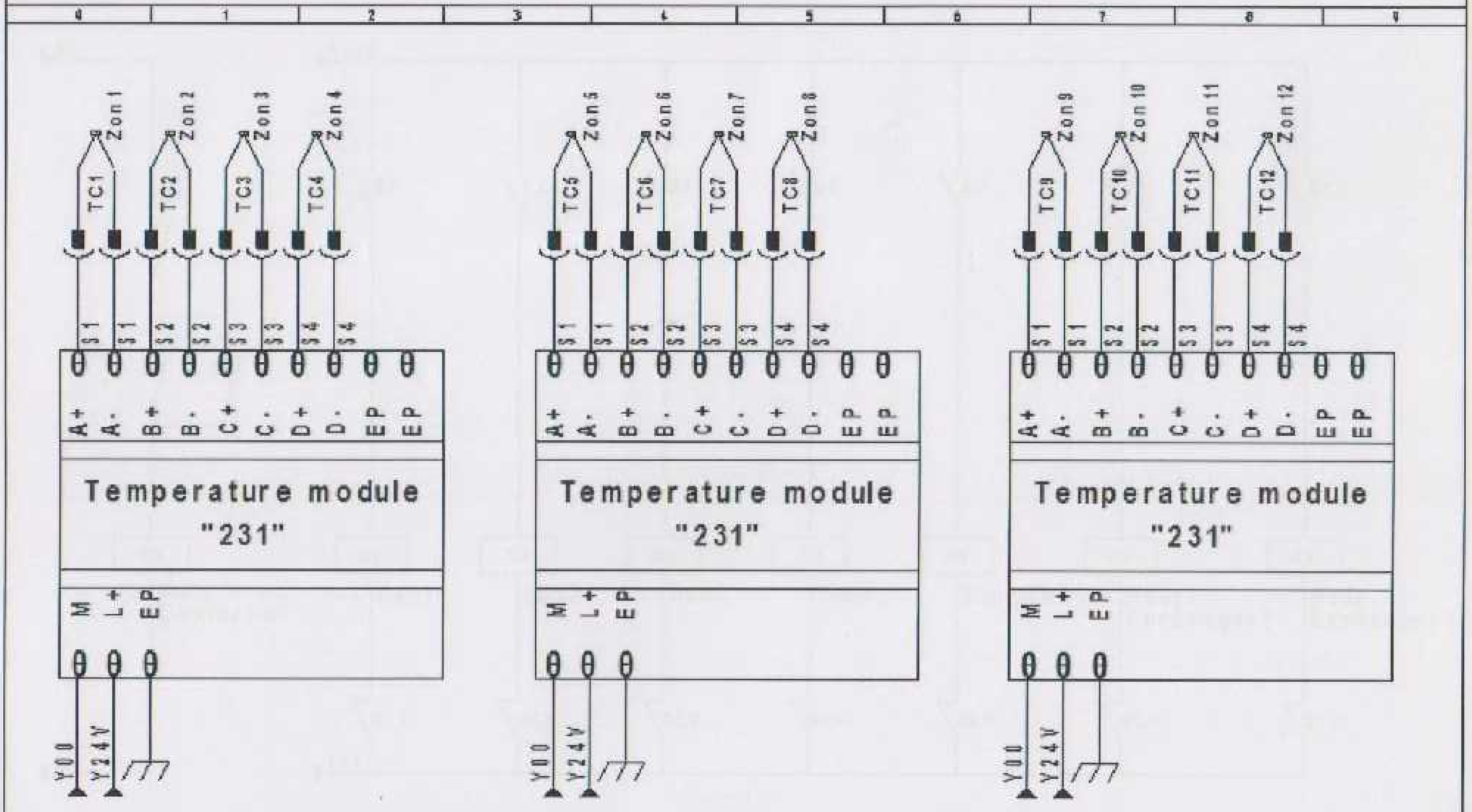

Siemens PLC s7200 "CPU_224XP"
"0-10 V"
V00
V01
M I V M A+ B+
Y00
Y24V
SSR1
SSR2
SSR3
SSR4
SSR5
SSR6
SSR7
SSR8
SSR9
SSR10
F1
F2
F3
F4
F5
F6
F7
F8
F9
F10
1M
1L+
0.0
0.1
0.2
0.3
0.4
2M
2L+
0.5
0.6
0.7
1.0
1.1
EP
M
L+
1.2
1.3
1.4
1.5
X000
ENCH1
ENCH4
EM
Inv_S
Inv_F
Inv_T
Fan1
Fan2
Fan3
Fan4
Vacuum
Heate_EX1
Heate_EX2
OL1
OL2
OL3
OL4
OL5
OL6
OL7
P.S For Encoder
X24V
Control
Royal company
Extruder machine
Job no.
Extruder11
Date
3/26/2015
Drawing
Device
Location
Rev.
By
Sheet
2



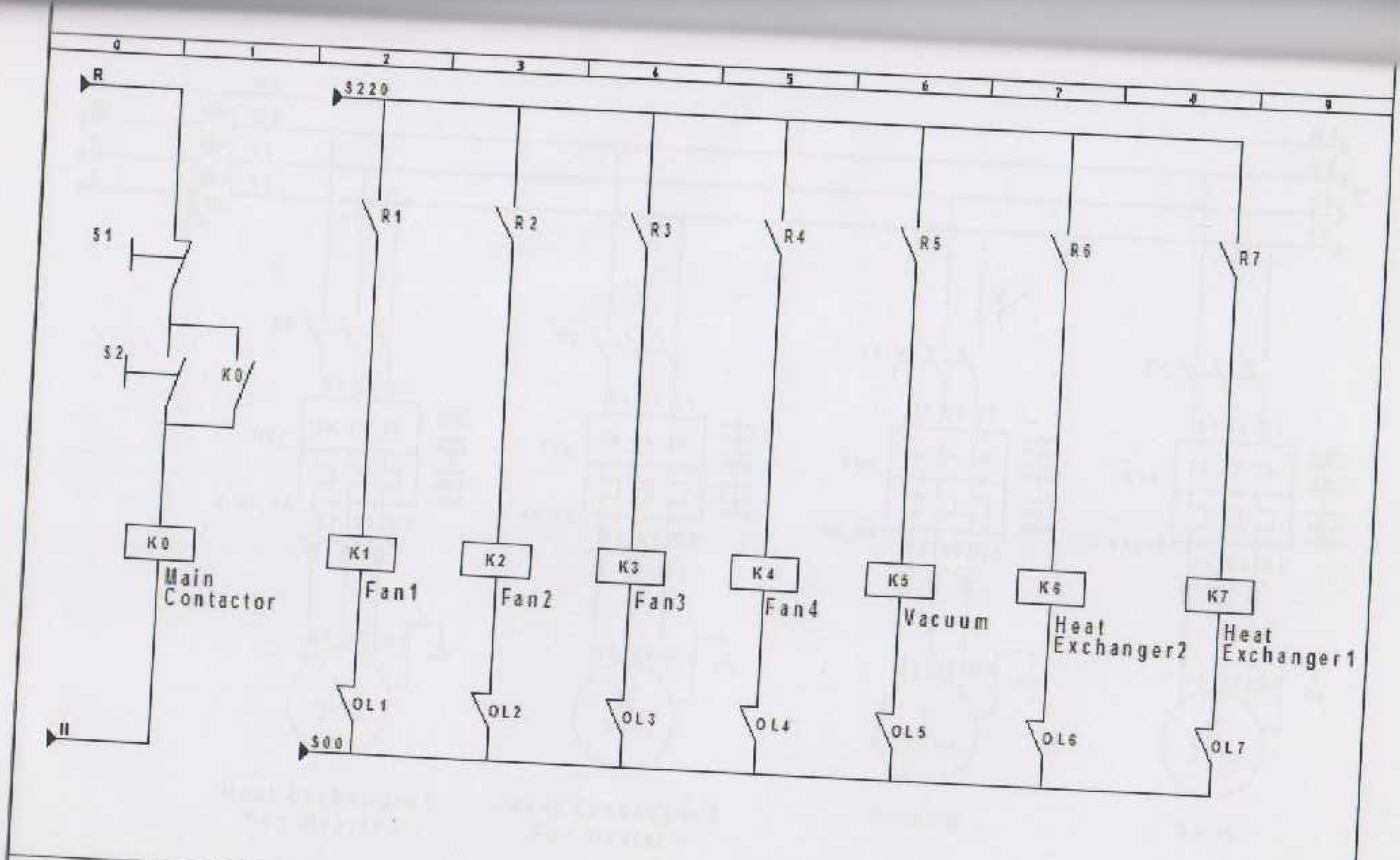

| Control | Royal company | Extruder machine | Job no. Extruder11 | Draw.no. | Rev: | By: |
|---|---|---|---|---|---|---|
| | | | Date 3/29/2015 | Device | Location | Sheet 3 |



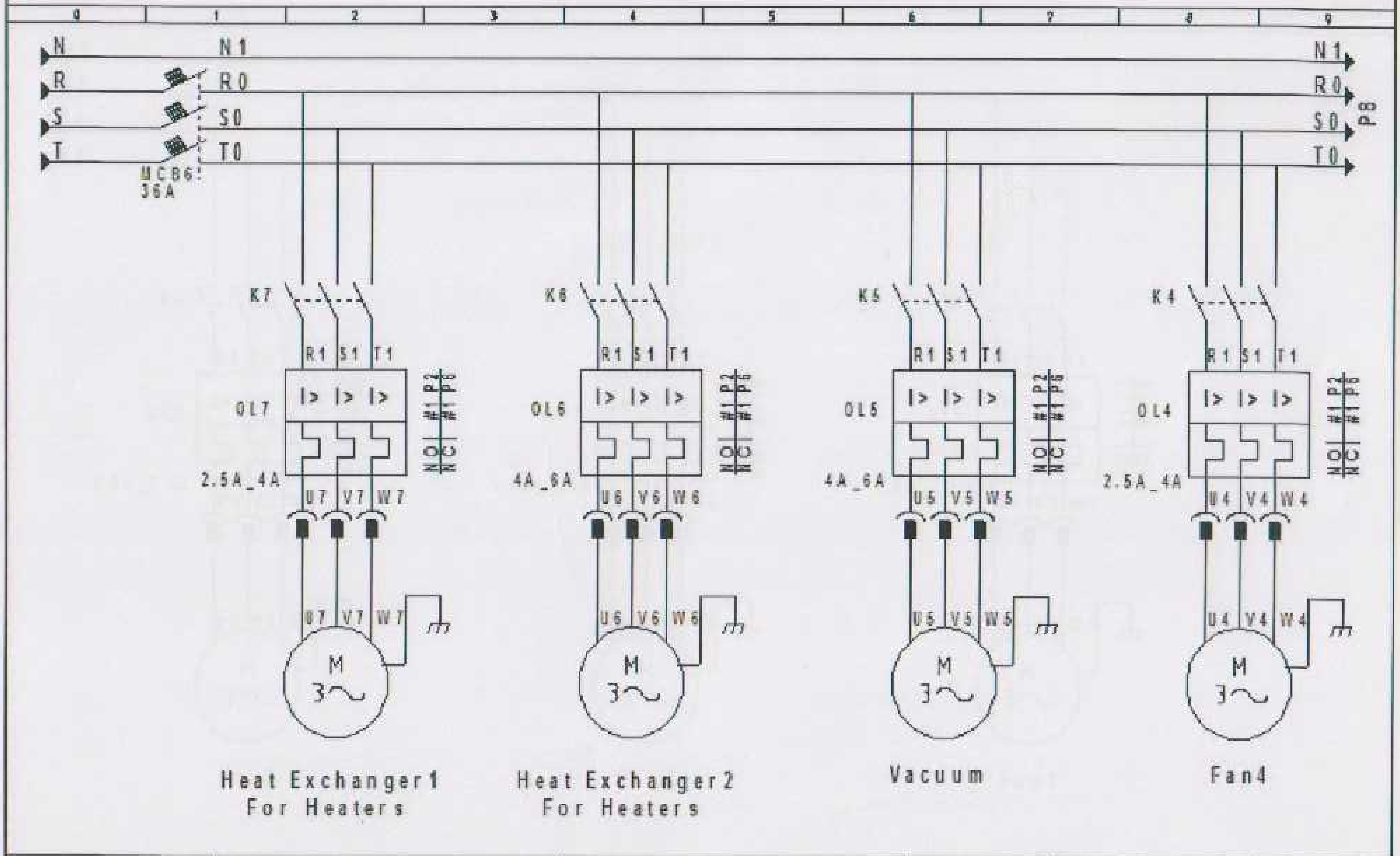

| Control | Royale company | Extruder machine | Job no. Extruder 02 | Draw.no. | Rev.: | By: |
|---|---|---|---|---|---|---|
| | | | Date 3/29/2015 | Devices | Location | Sheet 4 |



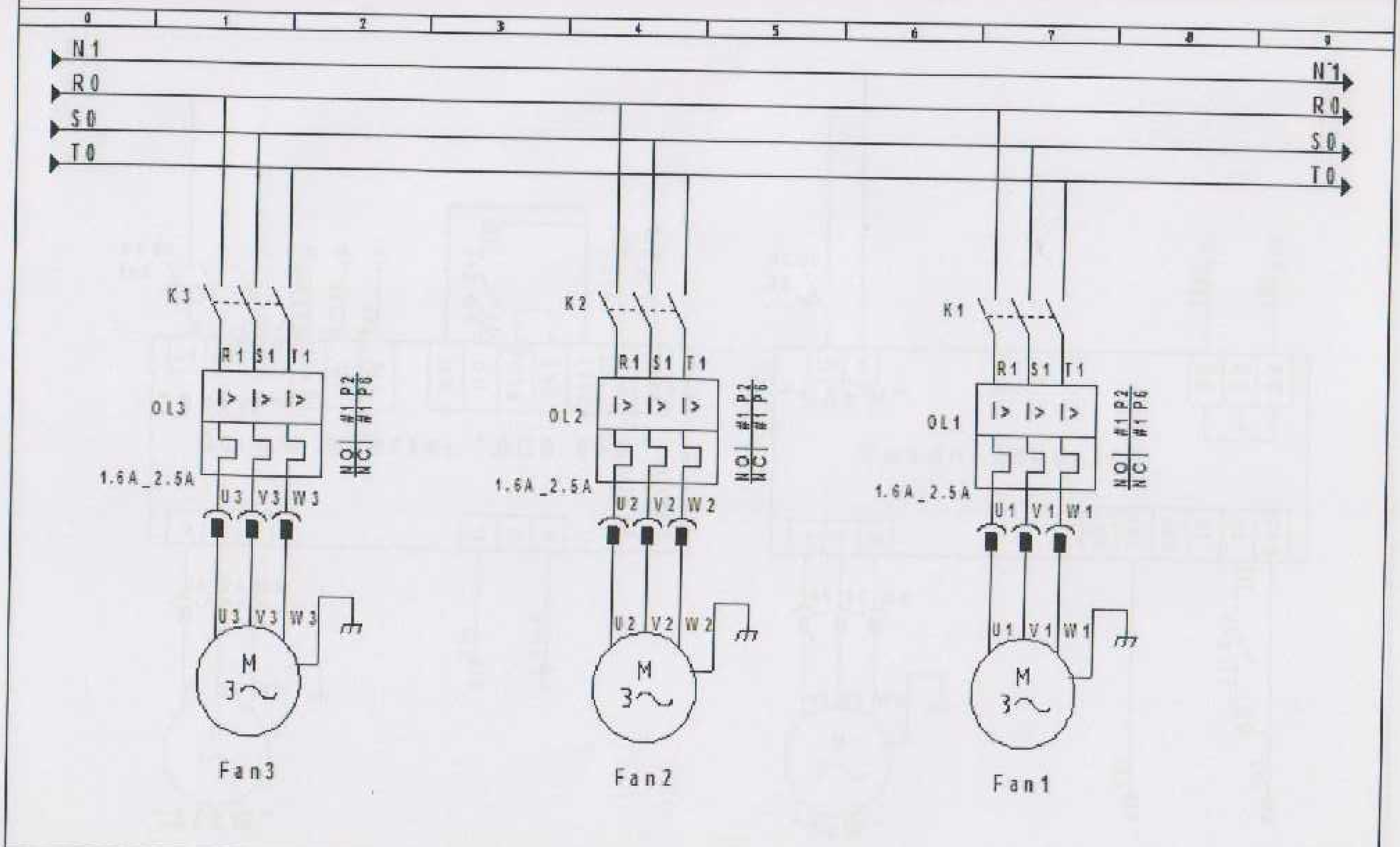

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Control | Royal company | Extruder machine | Job no. | Extruder12 | Draw.no. | | Rev.: | By: | |
| | | | Date | 3/29/2015 | Device | Location | | Sheet | 5 |



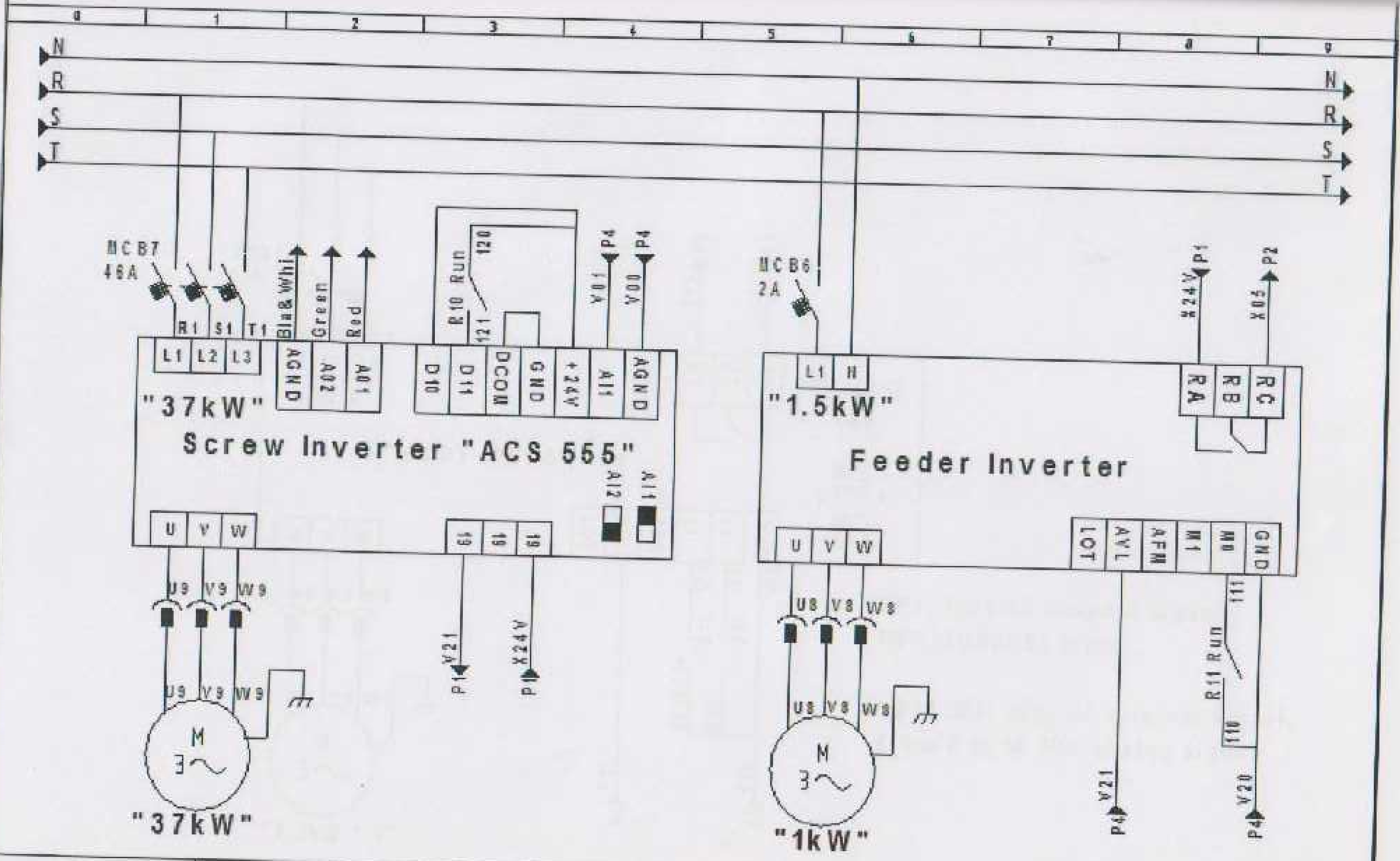

| Control | Royale company | Extruder machine | Job no. Extruder12 | Drw.no. | Rev.: . | By: . |
|---|---|---|---|---|---|---|
| | | | Date 3/30/2015 | Device: . | Location: . | Sheet 6 |



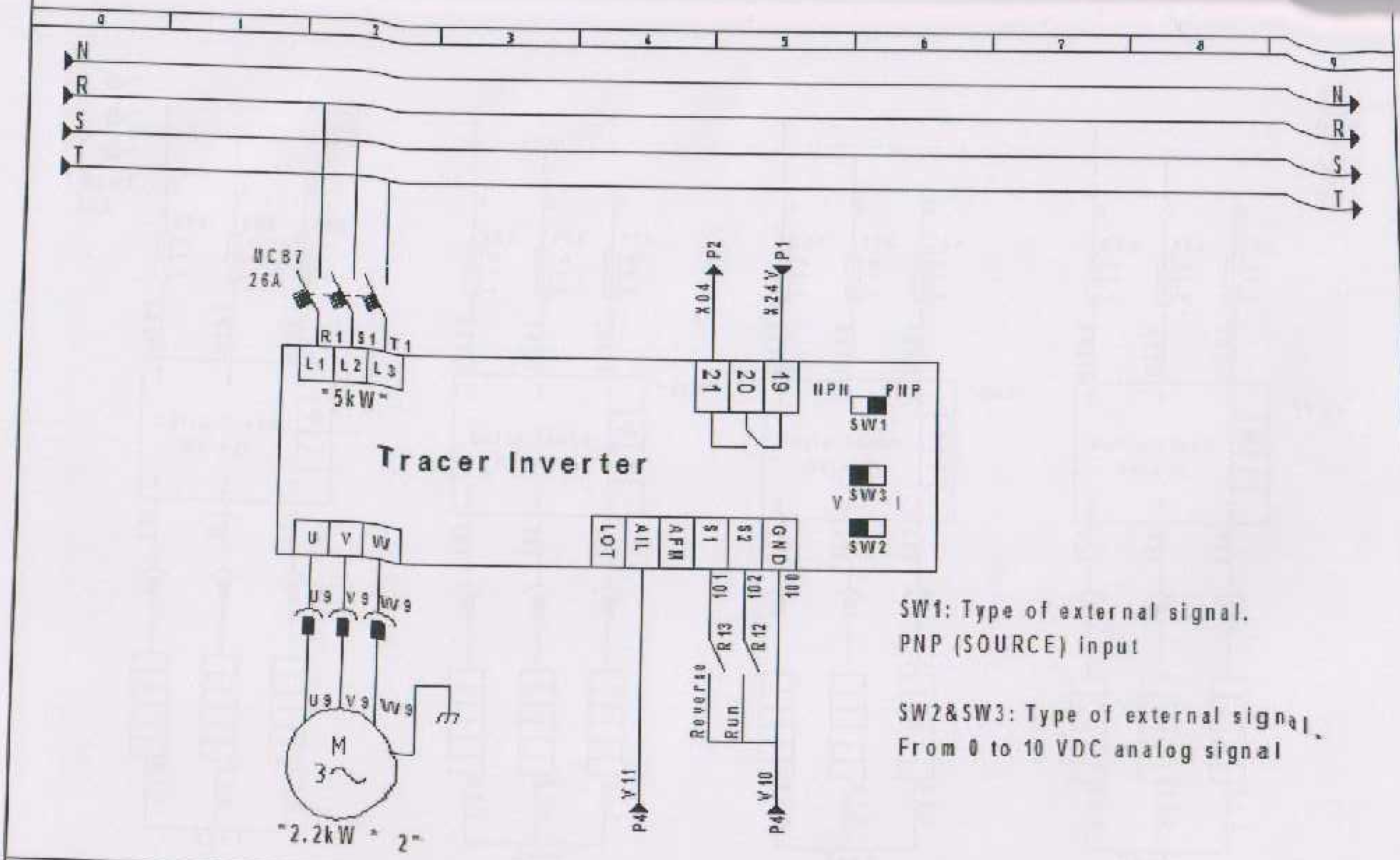

| | | | | | | |
|---|---|---|---|---|---|---|
| Power | Royal company | Extruder machine | Job no. Extruder13 | Drav.no. | Rev.: | By: |
| | | | Date 3/30/2015 | Device | Location | Sheet 7 |




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Power | : Royal company | : Extruder machine | Job no. Extruder13 | Draw.no. | Rev.: | By: |
| | | | Date 3/30/2019 | Device | Location | Sheet 8 |



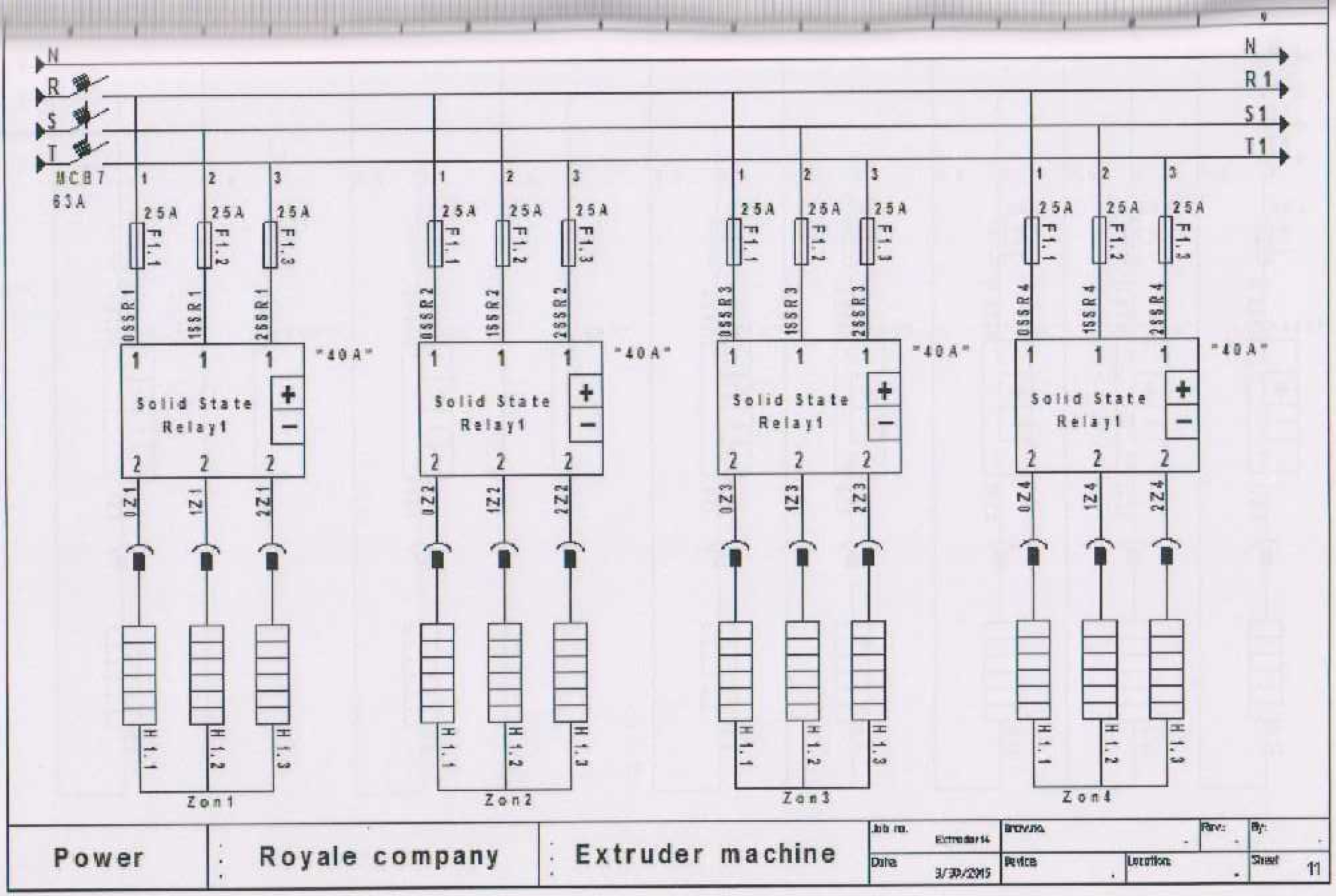

| | | | | | | |
|---|---|---|---|---|---|---|
| Power | : Royal company | : Extruder machine | Job no. Extrudar13 | Drawing no. . | Rev.: . | By: . |
| | | | Date 3/30/2015 | Device . | Location: . | Sheet 9 |

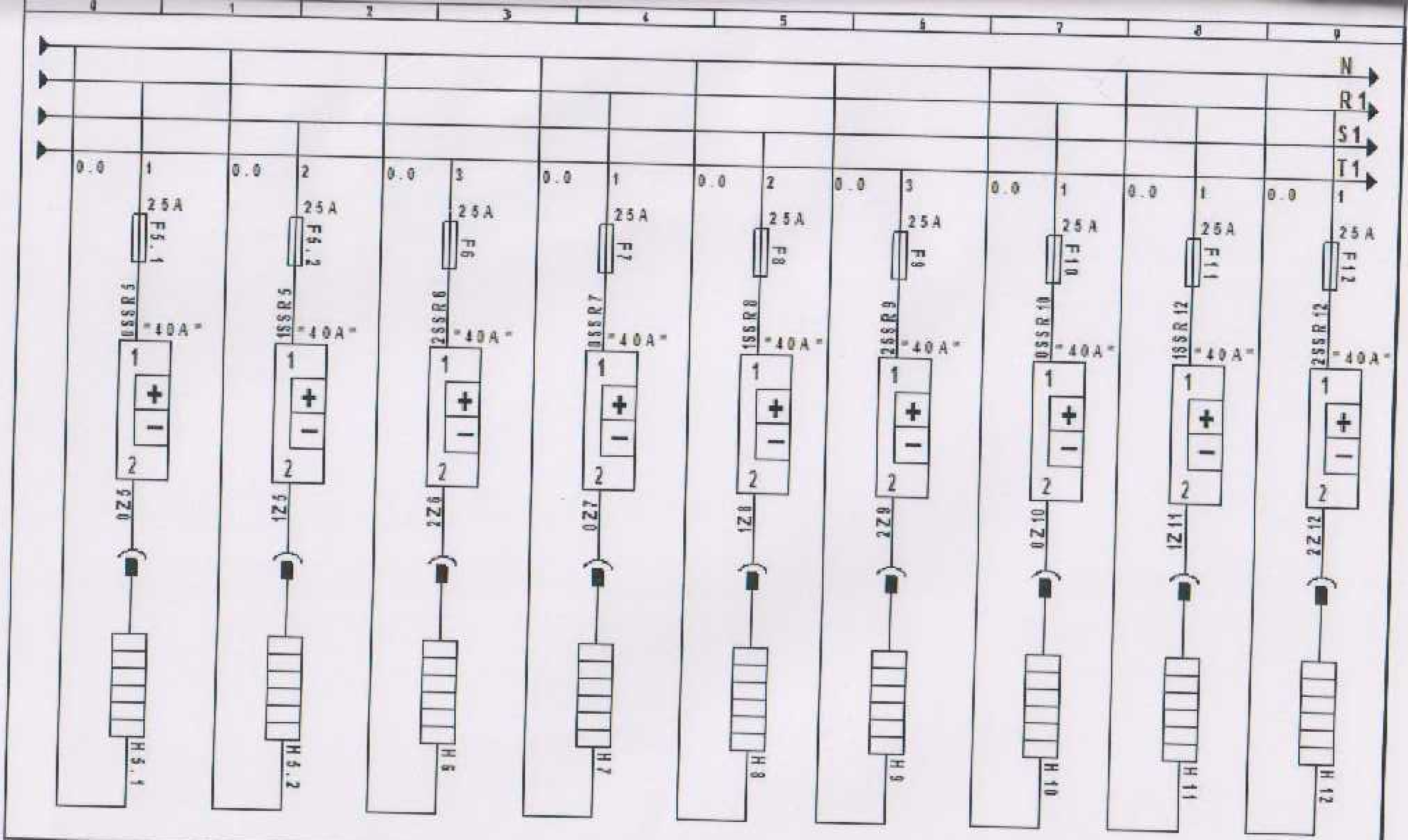



SW1: Type of external signal.
PNP (SOURCE) input

SW2&SW3: Type of external signal.
From 0 to 10 VDC analog signal

| Power | : Royal company | : Extruder machine | Job no. Extruder14 | Draw.no. | Rev. | By: |
|---|---|---|---|---|---|---|
| | | | Date 3/30/2015 | Device | Location | Sheet 10 |


N
R
S
T
MCB7
63A
N
R1
S1
T1
25A
F1.1
F1.2
F1.3
0SSR1
1SSR1
2SSR1
0SSR2
1SSR2
2SSR2
0SSR3
1SSR3
2SSR3
0SSR4
1SSR4
2SSR4
Solid State Relay1
"40A"
0Z1
1Z1
2Z1
0Z2
1Z2
2Z2
0Z3
1Z3
2Z3
0Z4
1Z4
2Z4
H1.1
H1.2
H1.3
Zon1
Zon2
Zon3
Zon4
Power
: Royale company
: Extruder machine
Job no. Extruder14
Date 3/30/2015
Drawing
Revise
Location
Rev:
By:
Sheet 11




| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Power | : Royal company | : Extruder machine | Job no. Extruder14 | Drawing . | | Rev.: . | By: . |
| | | | Date 4/19/2015 | Device . | Location . | | Sheet 12 |