Palestine Polytechnic University

College of Engineering and Technology

Electrical and Computer Engineering Department

Industrial Automation Engineering

Graduation Project

Automated rescue system for children in

private home swimming pools

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In accordance with the recommendations of the project supervisor and the acceptance of all examining committee members this project has been submitted to the department of electrical and computer engineering in the college of engineering and technology in partial fulfillment of the requirements of the bachelor degree.

Project supervisor signature

…………………………

Committee signatures

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Department head signature

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كلمة شكر

لا بد لنا ونحن نخطو خطواتنا الاخيره في الحياة الجامعيه من وقفه نعود بها الى اعوام قضيناها في رحاب جامعتنا مع اساتذتنا الكرام الذين قدموا لنا الكثير باذلين جهودا كبيره لتبعث الامه من جديد .... وقبل ان نمضي نقدم اسمى ايات الشكر والامتنان والتقدير والمحبه الى الذين حملو اقدس رسالة في الحياه..... الى اساتذتنا الافاضل....

ونخص بالشكر والتقدير:

مشرفنا الدكتور رائد عمرو

والذي نقول له بشراك قول رسول الله صلى الله عليه وسلم

"ان الحوت في البحر والطير في السماء ليصلون على معلم الناس الخير "

كما ونتوجه بخالص الشكر لاساتذة هندسة الاتمته الصناعيه في جامعة بوليتكنك فلسطين

الى من علمونا التفائل والمضي الى الامام

الى من وقفوا بجانبنا عندما ضللنا الطريق

الى

د. سمير خضر   د.عبد الكريم داود

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Abstract

قمنا بتصميم نظام حمايه اتوماتيكي لمنع الاطفال من الغرق في برك السباحه المنزليه. حيث قمنا بتصيم نموذج مصغر لبركة سباحه وقمنا بتطبيق النظام على هذا النموذج .يبدا النظام بعملية الكشف للشخص الموجود على حافة البركه .عملية الكشف تتم من خلال ثلاث حساسات مرتبه بشكل عمودي في ابراج موجوده على الزوايا الاربعه للبركه .عندما يقطع الشخص حساس او اثنين يكون طفل وعندما يقطع ثلاثه يكون بالغ.

في حالة كون الشخص طفل ترسل هذه الحساست اشاره الى المتحكم المبرمج والذي يقوم باعطاء اشاره الى ملف الصمام لرفع صفيحه مثقبه موجوده في قاع البركه . تقوم هذه الصفيحه برفع الطفل. كذلك يرسل المتحكم اشاره الى نظام التحذير ليعمل وينبه الاهل عن الطفل.

We designed an automated system to rescue the children from drowning into private home swimming pools, the design was applied to a prototype of a swimming pool. The system begins with the detection operation for the human who stands on the pool edge. The detection operation is accomplished by using four towers . Each edge has a tower, and each tower has three optical sensors arranged in a vertical way .When the person cuts one or two of the lower sensors, he is a child. If he cuts three sensors he is adult.

In the case of a child the sensors send a signal to the controller which gives a signal to the solenoid valve to lift up a rescue plate form that exists in the bottom of the pool. This plat carries the child. Also the controller sends a signal to the alarm system which warns the family to come to take the child from the plate form.

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Introduction

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1.2 Literature review.

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1.1 Introduction.

In recent years there is an increasing of numbers of families that have a swimming pool in their homes. No doubt those private swimming pools represent an entertainment facility which increases the life quality of people, but in the same time, private swimming pools can be a source of serious or even deadly incidents specially for children in case of the absence of adult observation.

This project aims to solve the above problem, and build a solution for it by building an automated rescue system around the pool. This system is able to prevent the child from drowning into the pool, in addition our system has the ability to differentiate between kids and adults, in the other words, our system remains in the ready station when adult comes to the pool for swimming. The idea of the project came originally from our supervisor Dr. Raed Amro from Palestine Polytechnic University.

Because of the financial difficulties to build our system on real pool, we applied it on a small model which mimics a private swimming pool.

1.2 Literature review.

A little number of projects that concentrate on the rescue process of this project, one of them is a united state patent called (swimming pool automation rescue device) accomplished by the inventor Vance Burroughs in November.10, 1999[1].

This patent has the same idea of our project but in difference rescue process. The detection way in this patent is accomplished by using one sensor. Electrical motors are used to lift up the rescue plate. Alarm system is not used in this patent.

Our project comes to upgrade this patent by using pneumatic cylinders instead of electrical motors which give our project a high degree in protection from electricity, also this project is more accurate in the detection way, three sensors are used instead of one sensor, alarm system is used in this project to warn the family.

1.3 Objective and motivation.

Increasing the number of incidents that occur to children in private home swimming pool especially when the absence of their families attention was a motivation for us to build an automated rescue system for children in order to minimize the number of these incidents'

The objectives of this project are:

1- To make the private pools more safe for children.

2- To reduce the number of drowning incidents in private pools.

3- To get the bachelor degree on the part of industrial automation engineering.

1.4 Project description.

The idea of the system is based on activation of a safety ground mounted on the bottom of the pool. In the normal state (there's no children around the pool) ,the plate remains in the bottom without moving .When a child comes to the pool, the sensors that mounted around the pool detect the child, so the plate is lifted up to prevent a child from drowning into the pool. Then the plat still in the above carrying the child with it, this process is achieved by using pneumatic cylinders mounted on the bottom. Also an alarm is sent to the people around the pool and in the home, this alarm brings the attention of the family. If there's a response from the family, an adult comes to take the child from the plate and reset the system. When the user makes a reset, the plate move down to the bottom and the system now is in the ready station.

If adult wants to swim in the pool, he has two choices, the first one is to turnoff the system and then go to the pool, in this case a red light existing around the pool is turned on to tell this human that the system is off, after he finishes the swimming, he activates the system and after activation, the system return to the ready station. In the second case the adult doesn't turns off the system and goes to swim, in this case the system remains in the ready station while the user swims.

Also the user has the ability to lifting up the plate when he wants to travel or to go out from the home by pressing a stand by switch.

1.5 Project cost.

Following are the total cost of the project.

Table (1.1): Budget descriptions

Item	Quantity	Price / JD
Optical sensors (columns) -transmitter -reflectors	12	500 JD
Movable plate.	1	50 JD
A model of swimming pool	1	150 JD
TOTAL		**700 JD**

1.6 Schedule time

Following are the distribution of the work along 28 week.

Table (1.2): Schedule time.

week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Choosing project																
Collection data																
Data analysis																
Practical experiment																
System design																
Writing project text																

week	17	18	19	20	21	22	23	24	25	26	27	28
Mechanical part design												
Electrical circuits												
Plc programming												
calibration												

Chapter Two

Project scope and principle

2.1 Project scope.

2.2 Project principle.

2.1 Project scope

1-This project concentrates on private pools with rectangular dimensions.

2-The target faction is the children.

3-The rescue system focus on preventing the child from falling into the pool.

4-Child detection process is achieved by using electrical sensors existing on vertical towers mounted on the pool edges.

5-The lifting up process is achieved by pneumatic system

6-The system use sound and light alarms to bring the attention of the people around the pool and, at the home.

7- The system does not deal with driven incidents.

8- Solid plate form with holes made from plastic is used to carry the child.

2.2 Project concept.

The project is based on specific kind of swimming pools with regular shape like rectangular shape. As known in practical the swimming pools don't have regular dimensions and each swimming pool has a special dimension. We chose rectangular swimming pool with dimensions (7*4) m and highest of 1.25m, and because of the lack of a swimming pool for the application of the project, and the difficulty of building home swimming pools, We designed a prototype of a swimming pool.

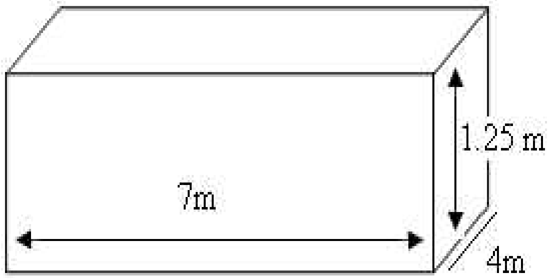


Figure 2.1: Real pool dimensions

The system cycle begins with the detection stage, which consists of optical sensors that transmit a light beams to the reflectors, which reflect the light and this light will be received by the same sensor.

If an object cuts the beam, the light will be diffused, and the sensors give output signals in the form of dc electrical voltage.

In order to differentiate between an adult and a child we decided to use four towers of optical sensors and mount them on the pool edges, each edge has a tower and each tower has three optical sensors arranged in the tower in a vertical way. If one or two of the lower sensors that exist in any tower gives an output, the person who stands on the edge is a child. The output signals of the sensors is sent to the programmable logic controller which gives an output to the pneumatic system to lift up a safety ground as shown in figure 2.2, in the same time an alarm is sent to the people around the pool and in the home. If the three sensors that exist in any tower give an output the person who stands on the edge is adult .so the system remains in a ready station.

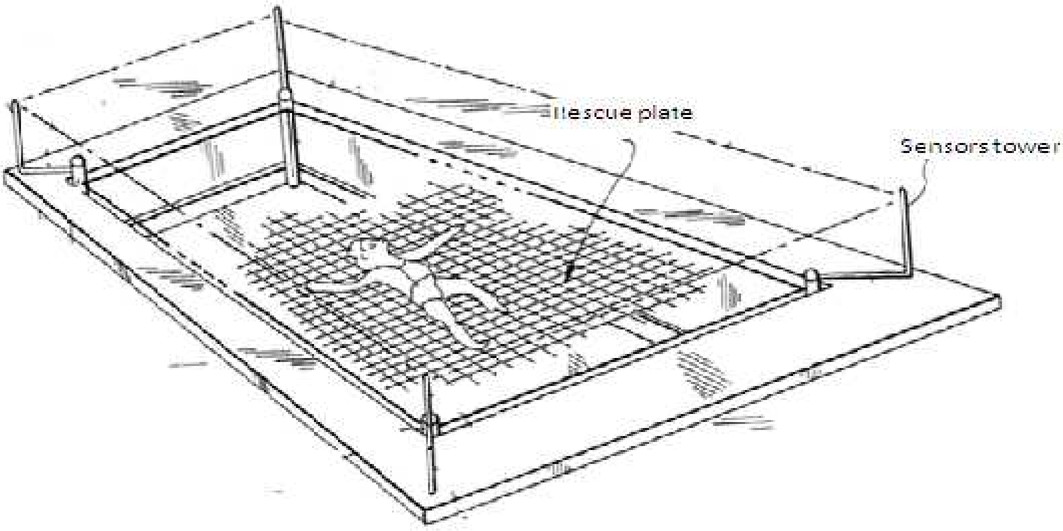


Figure2.2: The rescue station

The plate remains in the above until a person reaches the pool to take the child, and then reset the system by pressing a reset switch. When the reset finishes the plate move down to the bottom, a yellow light indication is used to confirm the reset operation. By this the system returns to the ready station (green light indication for this station).The figure below shows this station

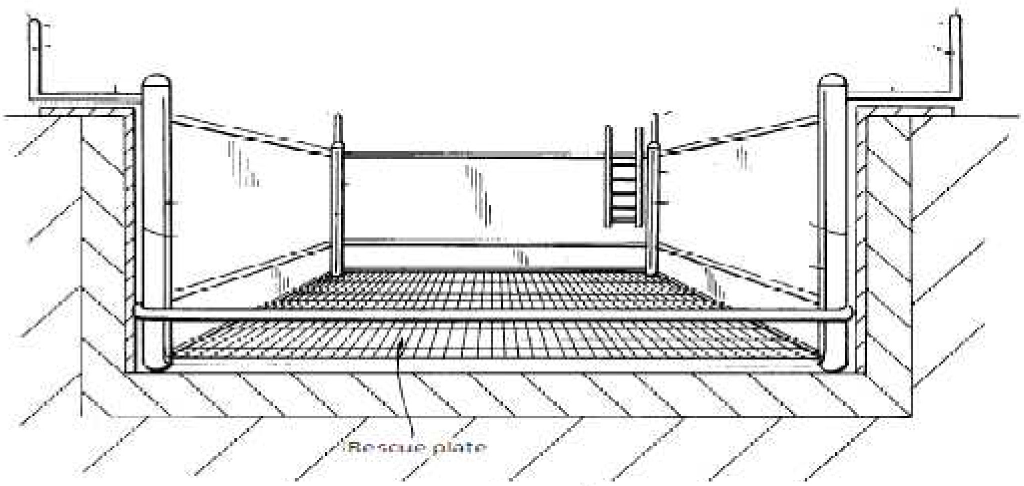


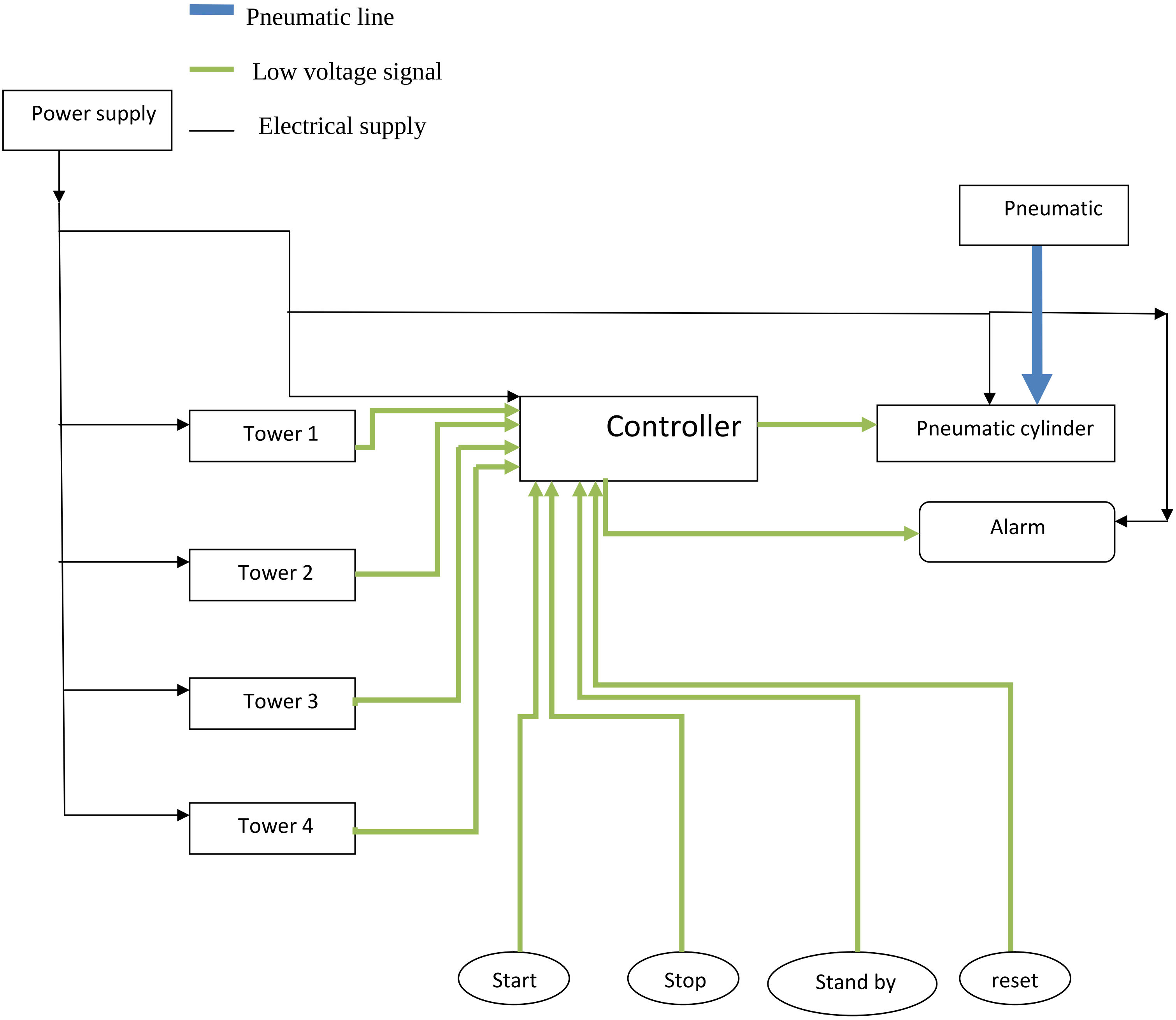
Figure2.3: The ready station

In the case of a child, alarm indications are used to warn the people in the periphery of the pool and in the home. These indications take a form of two buzzers with light devices, one of them in the home to warn the people in the home, and the other one in the pool periphery to warn the people around the pool.

When the user wants to swim, he deactivates the system by pressing a stop switch, at this moment a red light existing near the pool is used to indicate that the system is off, after he finishes the swimming, he presses a run switch to return the system to the ready station.

In addition, our system can be activated when the user wants, for example the family wants to go out from the home, and in this manner the user presses a stand by switch to raise the plate. An orange light is used to confirm this operation.

Following are the general bloke diagram of the rescue operation.



Following are the general flowchart of the system.

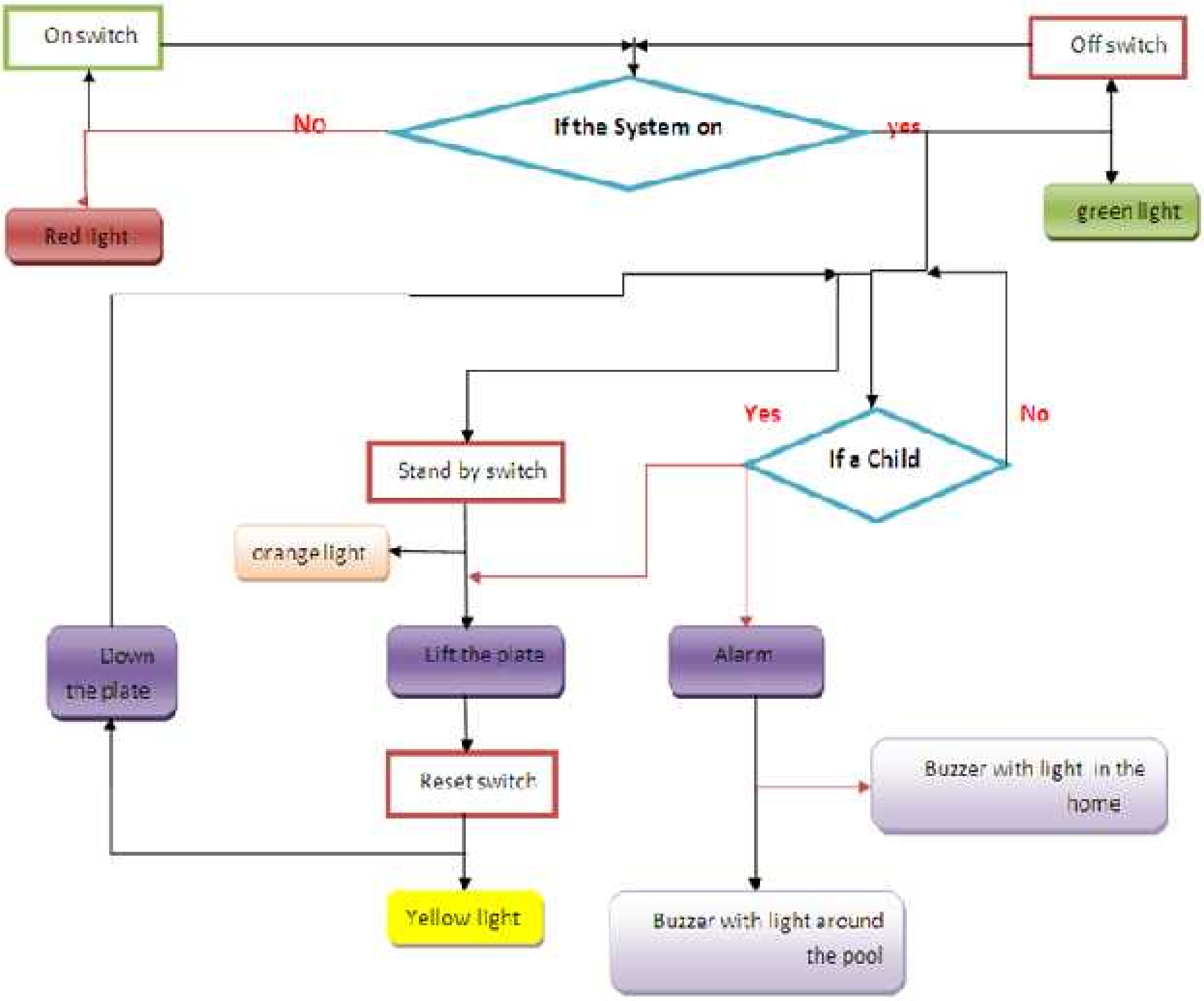


Figure 2.4: System flowchart

The general bloke diagram of the detection process for any tower.

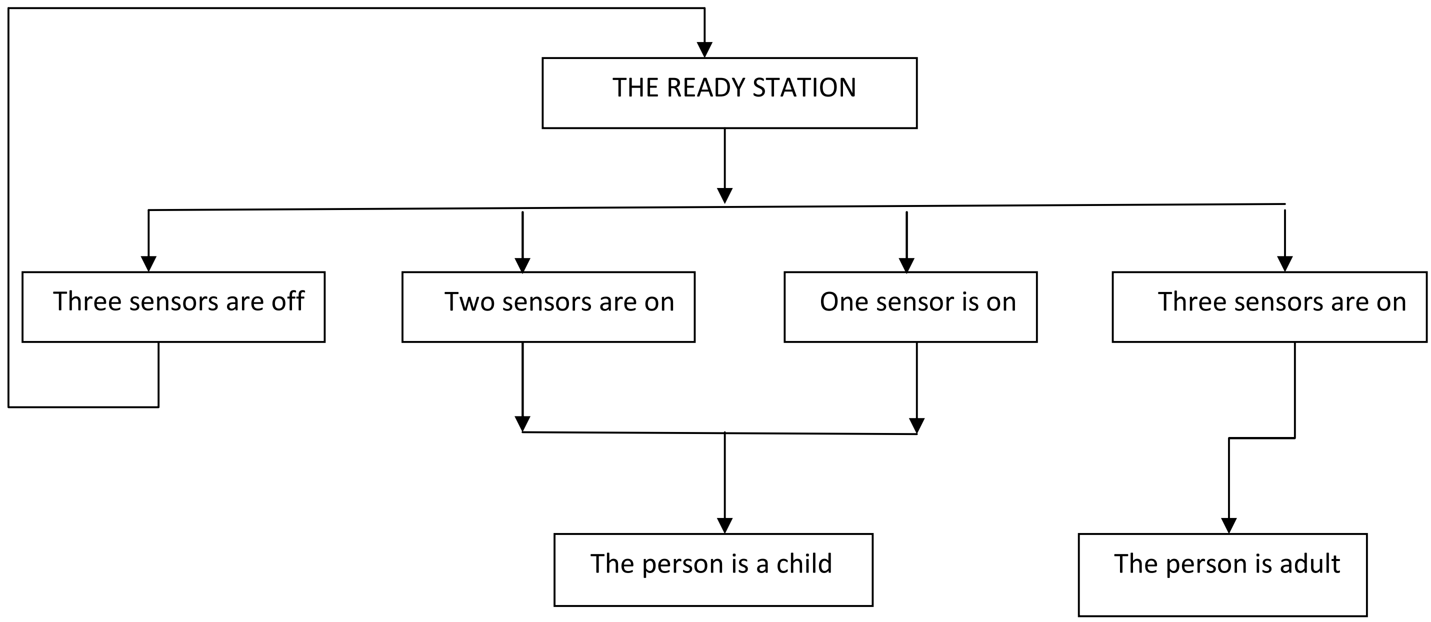


Figure2.5: The detection bloke diagram

Chapter Three

Project theory

3.1 The optical sensors

3.2 The control system.

3.3 Mechanical system

3.3.1 Fluid theory.

3.3.2 Pneumatic cylinders.

3.3.3 Pneumatic valves.

3.1 The optical sensor.

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The function of the optical sensors is to detect the presence of the person. We use Optical sensors that require both a light source (emitter) and detector. Emitters will produce light beams in the visible and invisible spectrums using LEDs and laser diodes. Detectors are typically built with photodiodes or phototransistors. The emitter and detector are positioned so that an object will block or reflect a beam when present. This sensor needs two separate components, as shown in Figure (3.1). This arrangement works well with opaque and reflective objects with the emitter and detector separated by distances of up to hundreds of
Feet

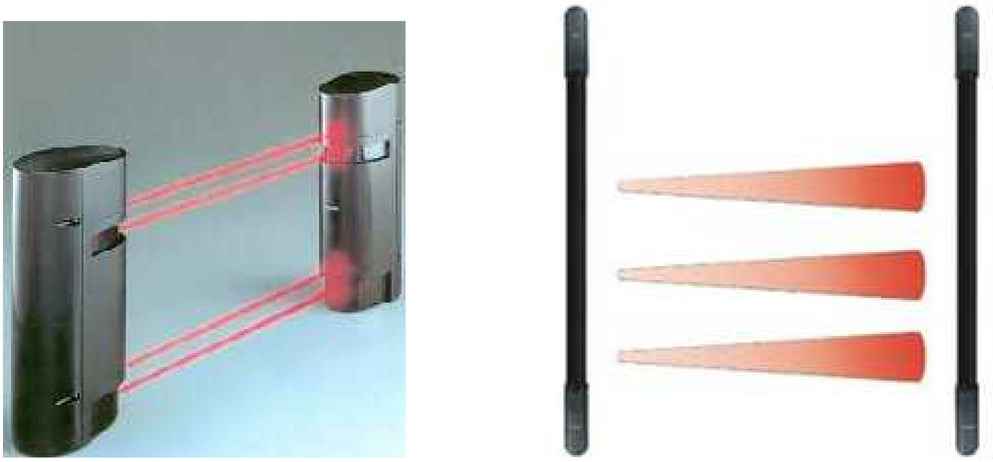


Figure 3.1: Optical sensor

But having the emitter and detector separate increases maintenance problems, and Alignment is required. A preferred solution is to house the emitter and detector in one unit. But, this requires that light be reflected back as shown in Figure (3.2) these sensors are Well suited to larger objects up to a few feet away.

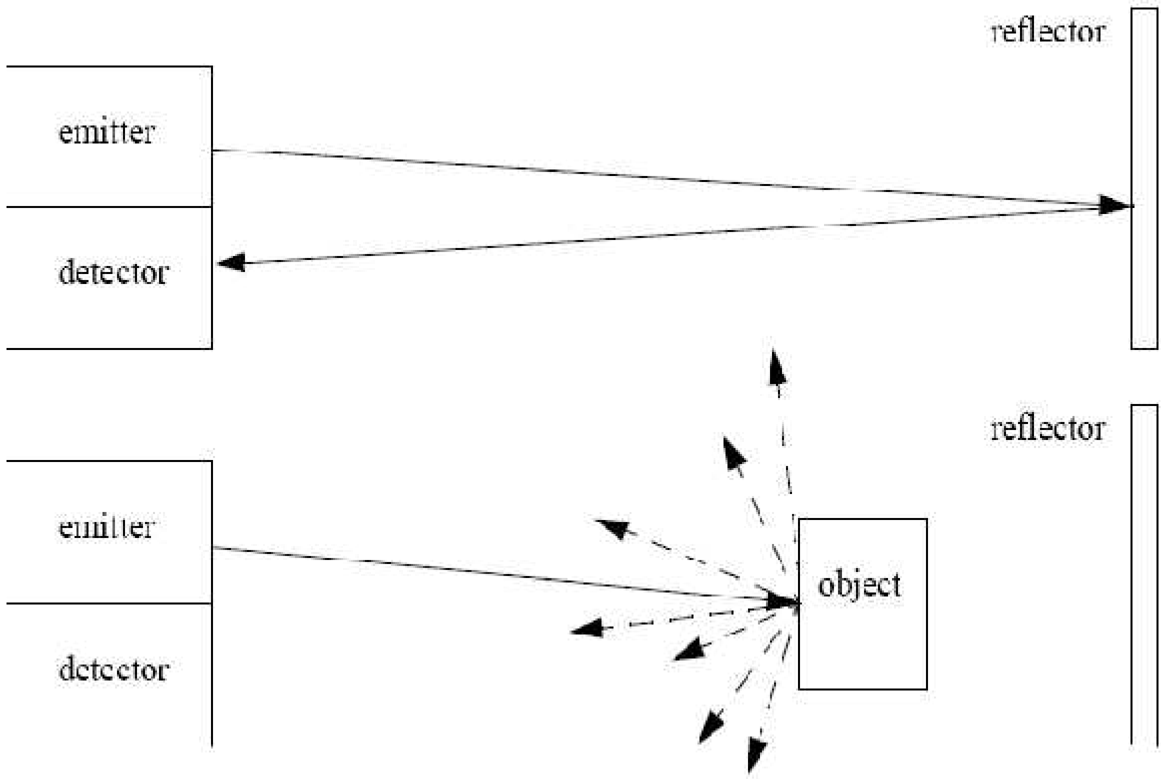


Figure 3.2: Optical sensor with reflector

There are two types of the above sensor sourcing and sinking sensors. The sinking sensors allow current to flow into the sensor to the voltage common, while sourcing sensors allow current to flow out of the sensor from a positive source. For both of these methods the emphasis is on current flow, not voltage.

When discussing sourcing and sinking we are referring to the *output* of the sensor That is acting like a switch. In fact the output of the sensor is normally a transistor that will Act like a switch (with some voltage loss). A PNP transistor is used for the sourcing output, And an NPN transistor is used for the sinking input.

A simplified example of a sinking output sensor is shown in Figure (3.3). The sensor will have some part that deals with detection, this is on the left. The sensor needs a voltage supply to operate, so a voltage supply is needed for the sensor. If the sensor has detected some phenomenon then it will trigger the active line. The active line is directly connected to an NPN transistor. If the voltage to the transistor on the *active line* is 0V, then the transistor will not allow current to flow into the sensor. If the voltage on the active line becomes larger (say 24V) then the transistor will switch on and allow current to flow into the sensor to the common[3].

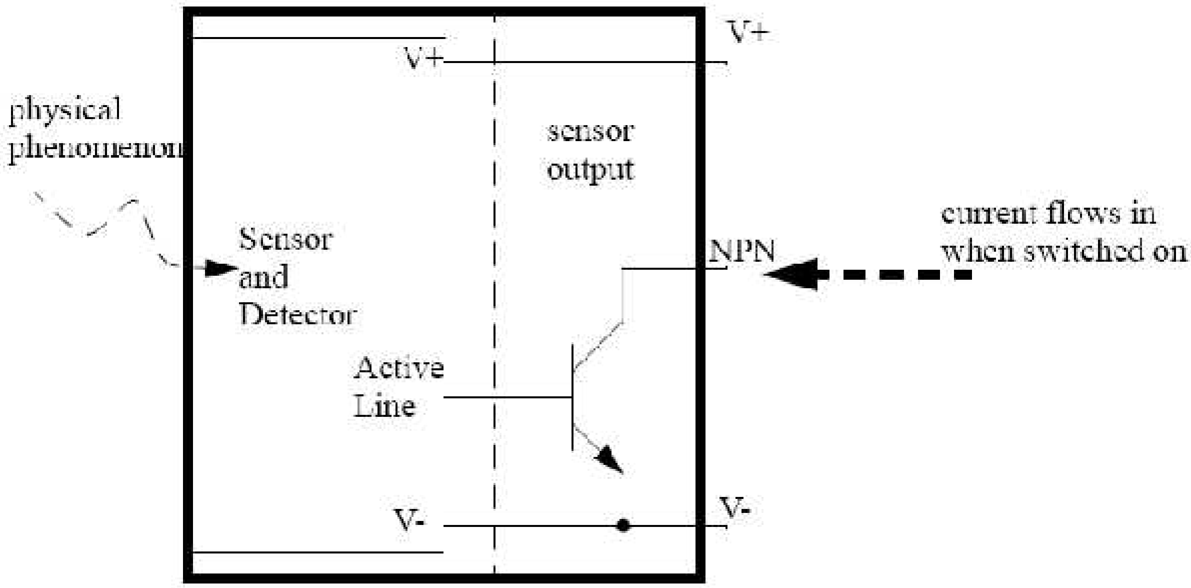
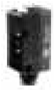
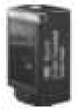


Figure 3.3: A simplified NPN/sinking sensor

There are many types of photoelectric sensors which are used in industry according to its usage and application. In view of the types of photoelectric sensors, the sensor, which serves the project, is **through beam sensors** and this sensor has several types, classified in accordance of sensing distance, response time, and other features. As shown in table below[4]. We decided to use **FEDM 16** through beam sensors because it is available in the market.

Table 3.1: Through beam sensors features

Product family	Picture	Housing	Sensing distance	Response time	Features
FECK 07 Through beam sensors		8x16,2x10,8 mm, plastic	2 m	< 0,5 ms	• ultra compact housing • sensing range adjustable via Teach-in • IP 65
FEDK 10 Through beam sensors		10,4x27x14 mm , plastic	5 m	< 1,4 ms	• compact housing • sensing range adjustable via potentiometer • IP 67
FEDK 14 Through beam sensors		14,8x43x31 mm , plastic	12 m	< 1,2 ms	• economy line • fix sensing distance • IP 67
FEDK 20 Through beam sensors		20x42x15 mm, plastic	6 m	< 0,5 ms	• cross-technology housing concept • IP 67
FEDK 26 Through beam sensors		25x80x58 mm, plastic	20 m	< 1 ms	• long range • IP 67
FEDM 16 Through beam sensors		15,4x50x50 mm , metal	8 m	< 1 ms	• rugged metal housing • fix sensing distance • IP 67

3.2 The control system

The main function of the control system it to decide whether the person on the edge of the pool child or not according to the signals those come from the optical sensors. In the case of a child the control system triggers a solenoid valve which actuates the pneumatic cylinder, and in the same time send signal to the alarm system to work.

Three available solutions

1) Relay systems
2) PLC systems
3) Microcontroller

Following are the comparison between them.

Table 3.1:Control systems comparisons

Characteristic	**Relay systems**	**PLC systems**	**Microcontroller**
Price per function	Fairly low	High	low
Physical size	Bulky	Very compact	Fairly compact
Operating speed	Slow	fast	Fairly fast
Electrical noise	Excellent	Good	Quite good
Capable of complicated operations	No	Yes	Yes
Ease of changing functions	Very difficult	simple	simple
Ease of maintenance	Poor- large number of contacts	Good	Poor
Installation	Time-consuming design and installation	Simple to program and install	Difficult to program and install

According to this comparison we decided to use **PLC system**.

3.3 Mechanical system.

The function of the mechanical system is to lifting up the rescue plate when a signal comes from the controller

Three available solutions achieve the above function.

1) Electric motors.
2) Pneumatic cylinders.
3) Hydraulic cylinders.

Following are the comparisons between them.

Table 3.3: Mechanical systems comparisons

Characteristics	Cost	Force density	Hazards	Complexity	Dirt's
Electric motors	High	Good	High	High	Low
Hydraulic system	High	Excellent	Low	Low	High
Pneumatic system	Low	Good	Low	Low	Low

According to above comparison we decided to use **Pneumatic cylinders.**

3.3.1 Fluid theory.

A water is a collection of molecules that are randomly arranged and held together by weak forces and by forces exerted by the walls of a pool, any object inside it will be affected by a forces perpendicularly on its surface as shown an the figure(3.4)[5]

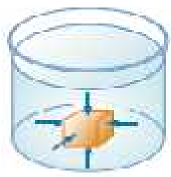


Figure3.4: Perpendicular forces

The pressure *P* of the fluid at the level to which the device has been submerged is defined as the ratio *F/A.*

The upward force exerted by water on any immersed object is called a buoyant force. The manner in which buoyant forces act is summarized by Archimedes's principle, which states that the magnitude of the buoyant force always equals the weight of the fluid displaced by the object. The buoyant force acts vertically upward through the point that was the center of gravity of the object.

Note that Archimedes's principle does not refer to the makeup of the object experiencing the buoyant force. The object composition is not a factor in the buoyant force.

If we have a cube of liquid as shown in the following figure 3.5 this cube is in equilibrium as it is acted on by two forces. One of these forces is the gravitational force F_g. But, this force is canceled with the buoyant force, so the magnitude of the buoyant force B exerted on the cube is exactly equal to the magnitude of F_g, which is the weight of the liquid inside the cube.

$$B = Fg \dots \dots \dots \dots (3.1)$$

Figure3.5:The bouncy force

If we replace the liquid cube with steel cube, the liquid surrounding a cube behaves in the same way no matter what the cube is made of. Therefore, the buoyant force acting on the steel cube is the same as the buoyant force acting on a cube of liquid of the same dimensions. In other words, the magnitude of the buoyant force is the same as the weight of the liquid cube; the same principle applies to submerged objects of any shape, size, or density. The pressure at the bottom of the cube is greater than the pressure at the top by an amount ρgh, where h is the length of any side of the cube[5].

The pressure difference ΔP between the bottom and top faces of the cube is equal to the buoyant force per unit area of those faces that is

$$\Delta P = \frac{B}{A} \ldots\ldots\ldots\ldots \quad 3.2$$

B: bouncy force

Therefore

$$B = \Delta P \; A = \rho g h \; A = \rho g v \ldots\ldots\ldots\ldots \quad 3.3$$

Where (v) is the volume of the cube and ρ is the water density

$B = Fg = \rho g v = Mg \ldots\ldots\ldots\ldots \quad 3.4$ Where M_g is the weight of the fluid in the cube

When an object is totally submerged in a fluid of density ρ_f, the magnitude of the upward buoyant force is

$B = \rho_f v o \, g \ldots\ldots\ldots\ldots \quad 3.5$ $where\ v$o Is the object volume

Now the resultant force on the object is

$$\mathbf{B - Fg = \rho_f - \rho o \;\; vo\, g \ldots\ldots\ldots\ldots \quad 3.6}$$

Where ρ_f: water density , ρo: object density.

3.3.2 Pneumatic cylinders.

To determine how much force an actuator can apply, we need to calculate the theoretical force for pneumatic piston shown in figure 3.6.

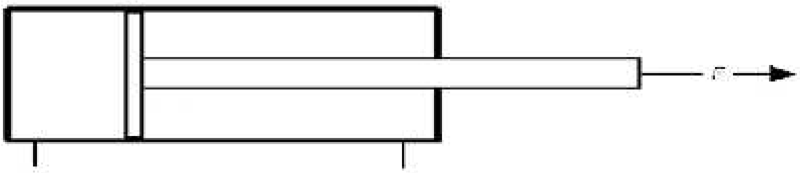


Figure 3.6: Pneumatic cylinder.

The piston force exerted by the cylinder is dependent upon the air pressure, the cylinder diameter and the frictional resistance of the sealing components. The theoretical piston force is calculated by the formula[6].

$$Fth = A * P \dots\dots\dots\dots \quad 3.7$$

Where

F_{th}: Theoretical piston force (N)

A : Useful piston area (m^2)

P : Operating pressure (Pa).

In practice the effective piston force is significant so frictional resistance should be taken into consideration when calculating the force.

For double acting cylinder the effective force due to forward stroke is

$$Feff = (A * P) - FR \dots\dots\dots\dots \quad 3.8$$

And for return stroke is

$$Feff = A1 * P - FR \dots\dots\dots\dots \quad 3.9$$

Where

F_{eff} : Effective piston force (N)

A_1 : Useful annular surface (m^2)

FR : Friction force (approx. 10% of F_{th}) (N)

The area of the piston surface calculated by the following equations

$A = (D^2 * \pi) /4$……….(3.10)

$A_1 = (D2 - d^{2)} \pi /4$………..(3.11)

Where

D: Cylinder diameter

d: Piston diameter

3.3.3 Pneumatic valves.

Control valves are devices which influence the path taken by an air stream. Normally this involves one or all of the following: opening the passage of air and directing it to particular air lines, cancelling air signals as required by blocking their passage and/or relieving the air to Atmosphere via an exhaust port**.**

A pneumatic system have a wide range of directional valves such as 5/3, 4/2, 3/2 way directional valves, in addition pneumatic systems have specially valves used to throttle the air, and non return valves, flow control valves. Following are brief description of the appropriate valves for this project.

1- 5/3 way valve

The 5/3-way valve has five working ports and three switching positions. With these valves, double-acting cylinders can be stopped within the stroke range. This means a cylinder piston under pressure in mid position is briefly clamped in the normally closed position and in the normally open position, the piston can be moved unpressurised. If no signals are applied at either of the two control ports, the valve remains spring cantered in mid position[6].

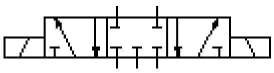


Figure 3.7: 5/3 way valve

2- Flow control valves

Flow control valves influence the volumetric flow of the compressed air in both directions. The throttle valve is a flow control valve. Throttle valves are used for speed control of cylinders. Care must be taken that the throttle valve does not close fully, cutting off air from the system.

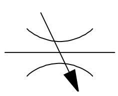


Figure 3.8: Flow control valve

In order to control the speed of the cylinder for one direction, a one way flow control valve is used. In this case the air flow is throttled in one direction only. A check valve blocks the flow of air in the bypass leg and the air can flow only through the regulated cross-section. In the opposite direction, the air can flow freely through the opened check valve. These valves are used for speed regulation of actuators and if possible, should be mounted directly on the cylinder.

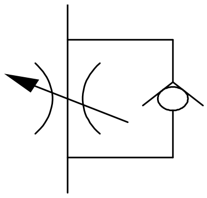


Figure 3.9 One way flow control valve

3- Quick exhaust valve

Quick-exhaust valves are used to increase the piston speed of cylinders. This enables lengthy return times to be avoided, particularly with single acting cylinders. The principle of operation is to allow the cylinder to retract at its near maximum speed by reducing the resistance to flow of the exhausting air during motion of the cylinder. To reduce resistance, the air is expelled to atmosphere close to the cylinder via a large orifice opening. The valve has a closable supply connection 1, a closable exhaust 3 and an outlet 2.

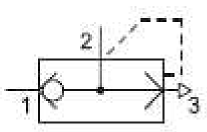


Figure 3.10 Quick exhaust valve

Chapter Four

Project design

4.1 PLC wiring and program.

4.2 Real pool fluid design.

4.3Prototype fluid design

4.4 Prototype mechanical design.

4.5 Pneumatic circuit.

4.1 PLC wiring and program.

The following wiring diagrams show the input and output wiring for all system components such as switches, optical sensors, output lamps, buzzers and the solenoid valve.

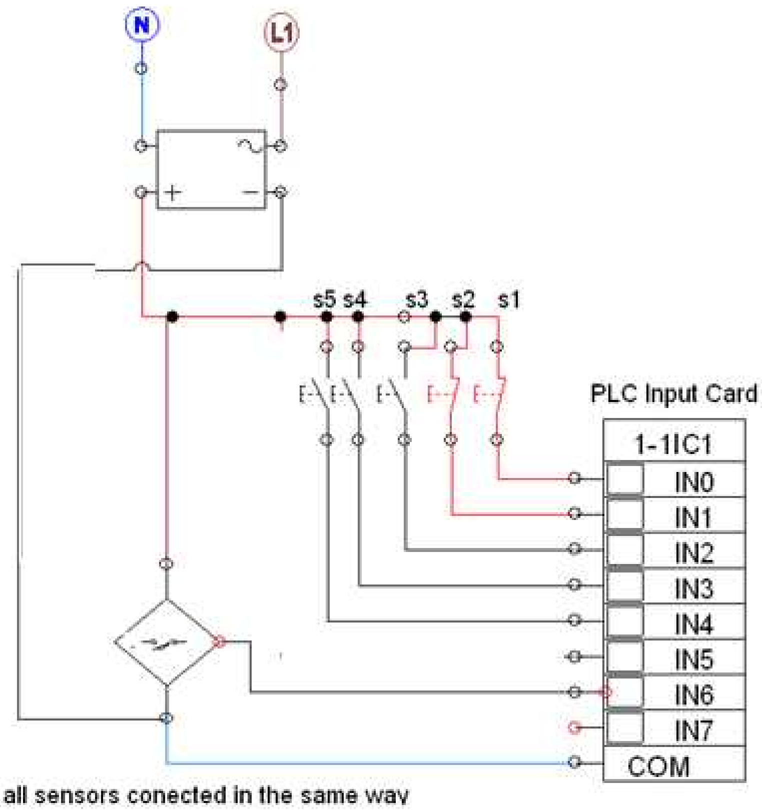


Figure 4.1: Input wiring

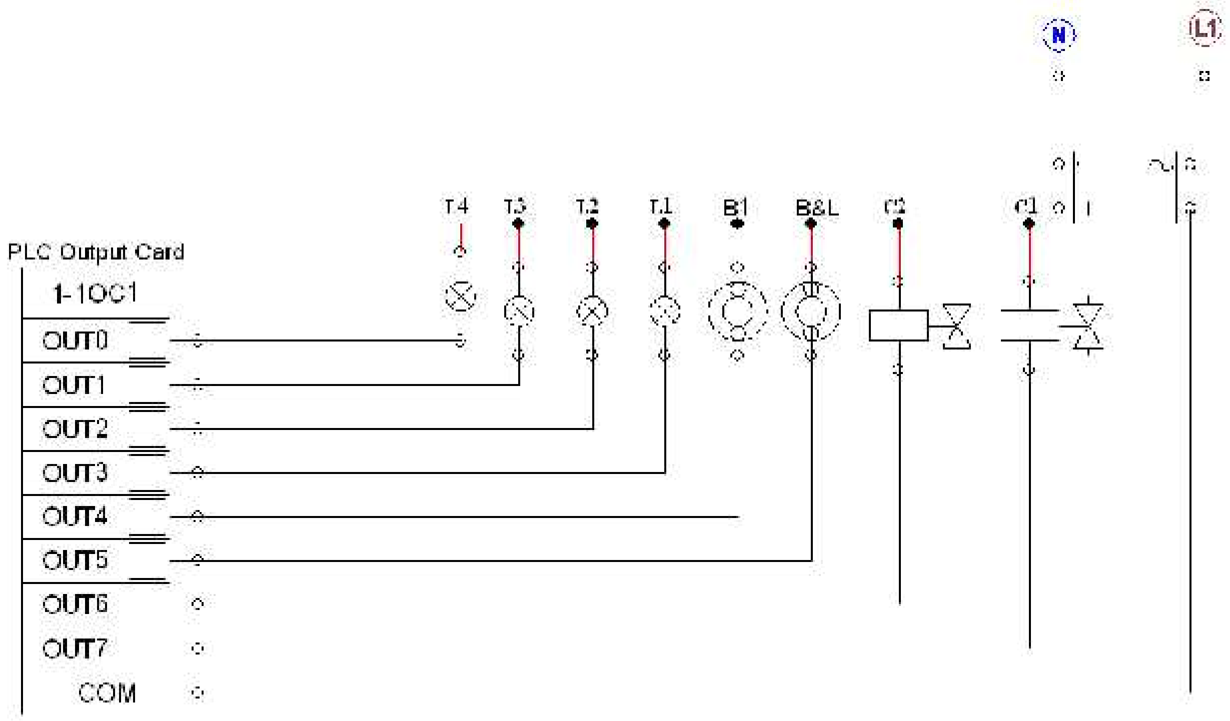


Figure 4.2: Output wiring

Input and output component table which are used in the system.

Table 4.1: Component list

S1	**Emergency switch**
S2	**Stop switch**
S3	**Run switch**
S3	**Reset switch**
S4	**Stand by switch**
Twelve lighting sensor	
L1	**Green light**
L2	**Red light**
L3	**Yellow light**
L4	**Orange light**
B1	**buzzer**
B&L	**Buzzer with light**
C1	**Up solenoid**
C2	**Down solenoid**

4.2 Real pool fluid design.

Now apply the equations of chapter three on the real pool with the following dimensions. (7*4) m and highest of 1.25m .we have two cases.

Case1: calculation with taking the buoyancy force into considerations.

We have a plate with volume of 0.2 m^3 calculated by Catia program. The plate is made from plastic with density of 1200 Kg/m^3. Water density is 1000 Kg/m^3. Compressor pressure is 6 Par (600KPa).

From equation (3.6)

B - Fg = *(1000 -1200)**9.8*0.2

*200*0.2 *9.8 = -392N*

= 392N downward.

So we need a force greater than 392N to lift up the plate.

And now from equation (3.8)

392= (P*A)-FR

392N= (600KPa*A)-0.1(600Kpa*A)

A=7.259 Cm2

D=3.04 cm.

The nearest standard diameter is 4cm.

Case 2: without using buoyancy force into consideration. (Neglect the effect of the bouncy force)

In this case we divide the plate into two parts in order to reduce the force required to accelerate the plate.

Total mass = 240 Kg .The mass of each half is 120 Kg.

Fg= Mg=1176N.

1176N= (600KPa*A)-0.1(600KPa*A).

A=21.8 $cm^{2.}$

D=5.265cm

We need two cylinders with 6cm diameter.

This calculation in forward stroke. In downward stroke we need force lower than 392N because the density of the plate material is greater than the density of the water.

There is no effective equation to find the speed of pneumatic cylinders because the air is able to be compressed so we find the average piston speed from the following chart

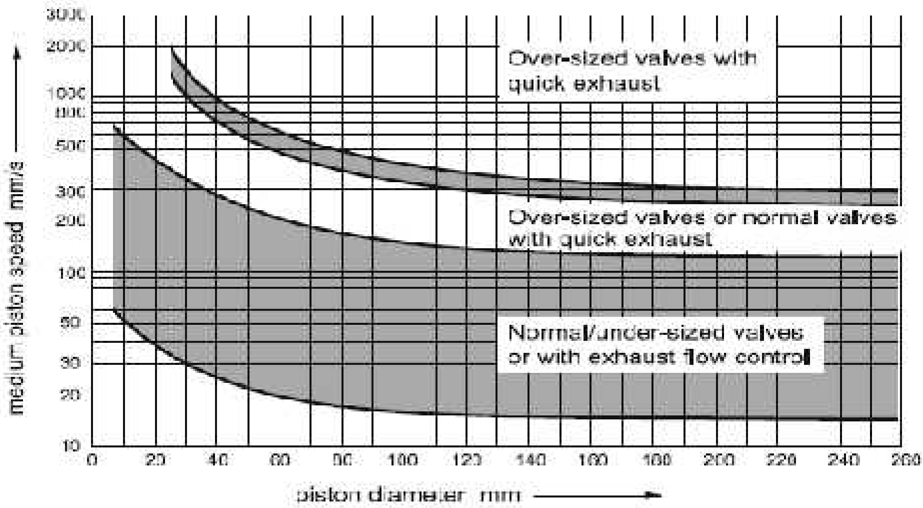


Figure 4.3: Piston speed[6]

For case1 the rang of the speed from 30mm/s to310mm/s. according to this information the rang of lifting up process is (4s to 41s). In order to decrease this time a higher pressure compressor can be used such as 8 pars, 12 pars. The second option of decreasing the lifting up time is to use the plate with density near the density of the water.

4.3 Prototype fluid design.

Case 1: calculation with taking the buoyancy force into considerations.

Plate volume = 0.008 m^3

B - Fg = (1000 -1200)*0.008 *9.8= -15.68

15.65 Downward

15.65N= (600KPa*A)-0.1(600KPa*A)

A= 0.29cm^2

D=0.819cm

Case2: without using buoyancy force into consideration. (Neglect the effect of the bouncy force).

Total mass = 9.6 Kg

F= Mg=94N.

94N= (600KPa*A)-0.1(600KPa*A).

A=1.74 cm^2

D=1.49 cm

This calculation in forward stroke in downward stroke we need force lower than 15.65N because the density of the plate material is greater than the density of the water.

For case1 Speed range from (60 mm/s to 700mm/s) and lifting up time (0.7s to 8.3s)

4.4 Prototype mechanical design.

This section talks about the mechanical parts of the prototype and elements used Also there are a detailed dimensions of the whole element used with directed positions.

Towers and pool model dimensions

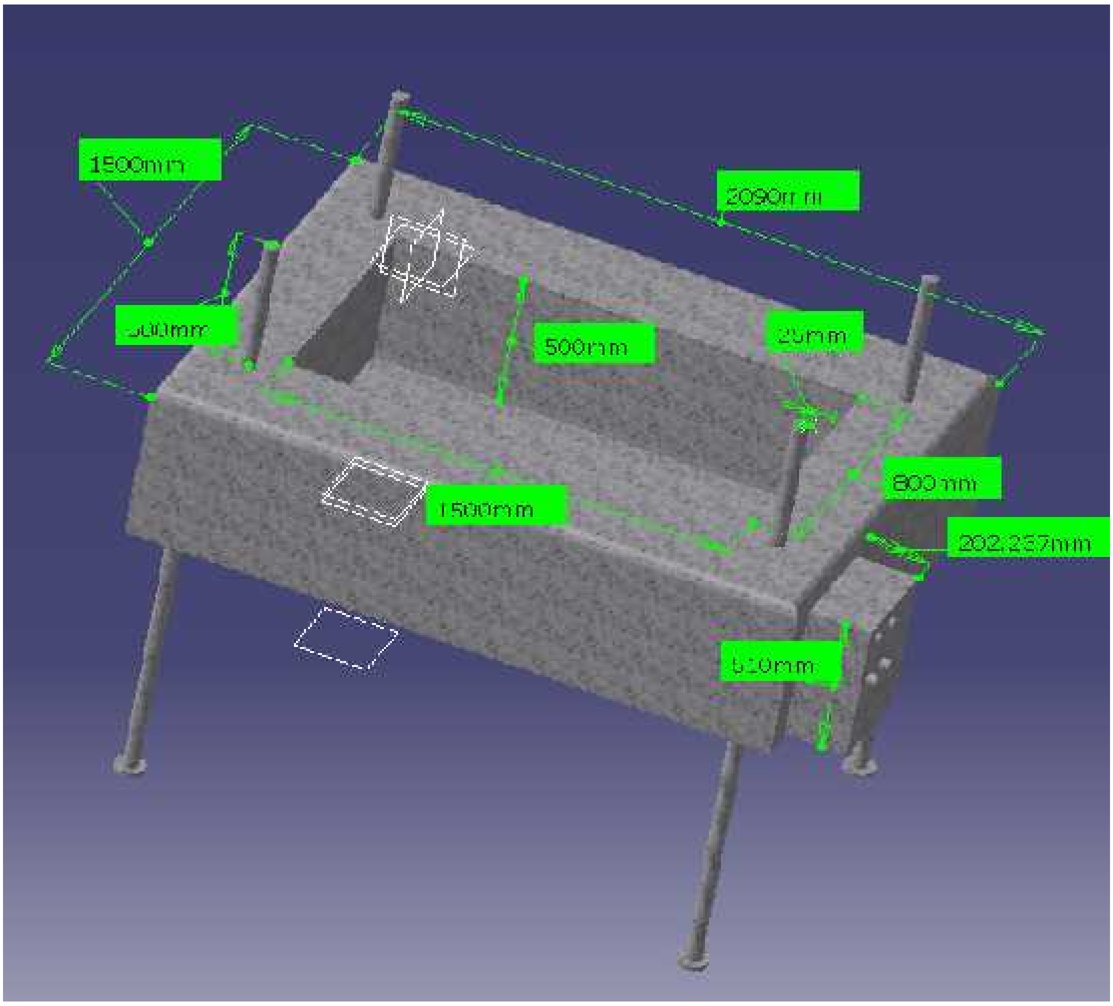


Figure4.4: Prototype mechanical design

Downward view of the model

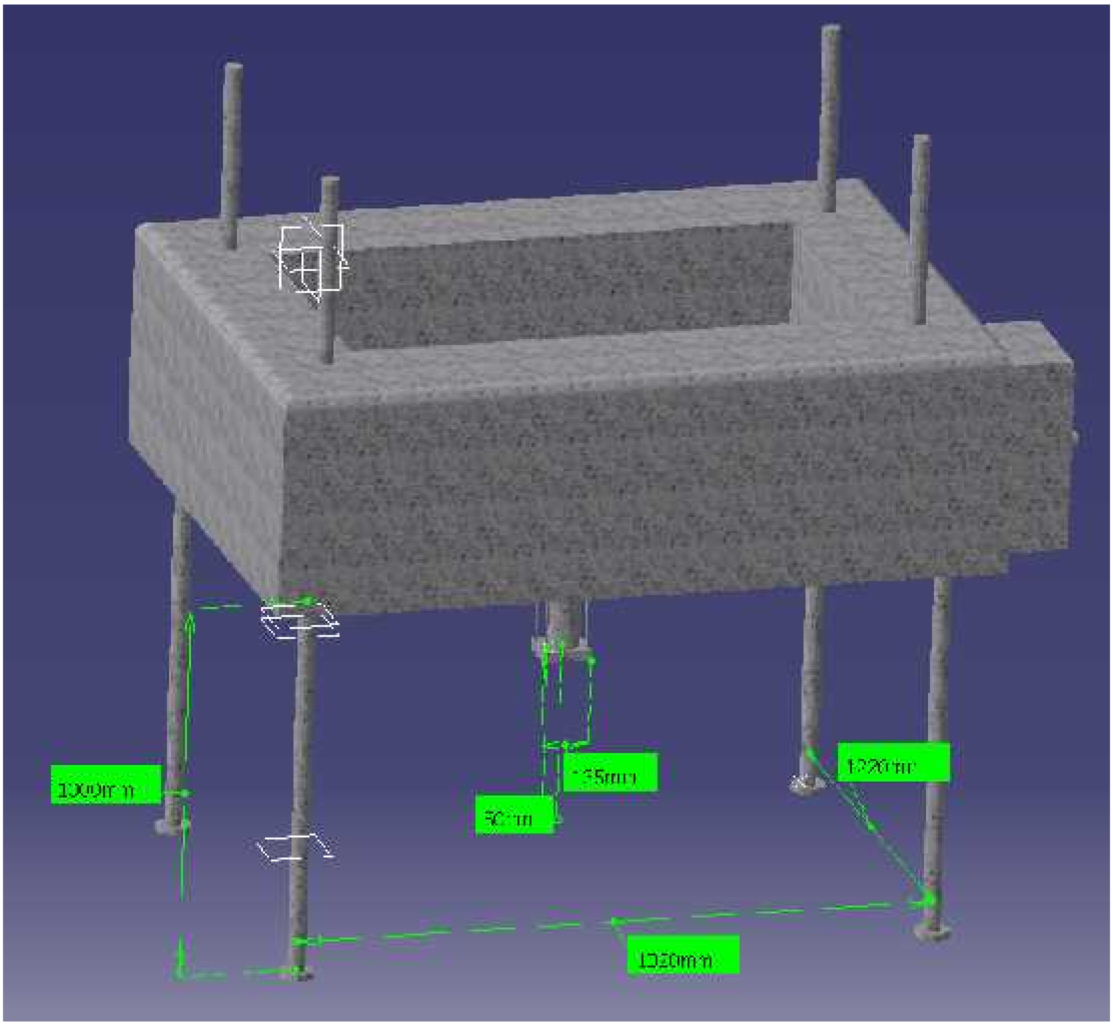


Figure4.5: Prototype down view

Plate dimensions.

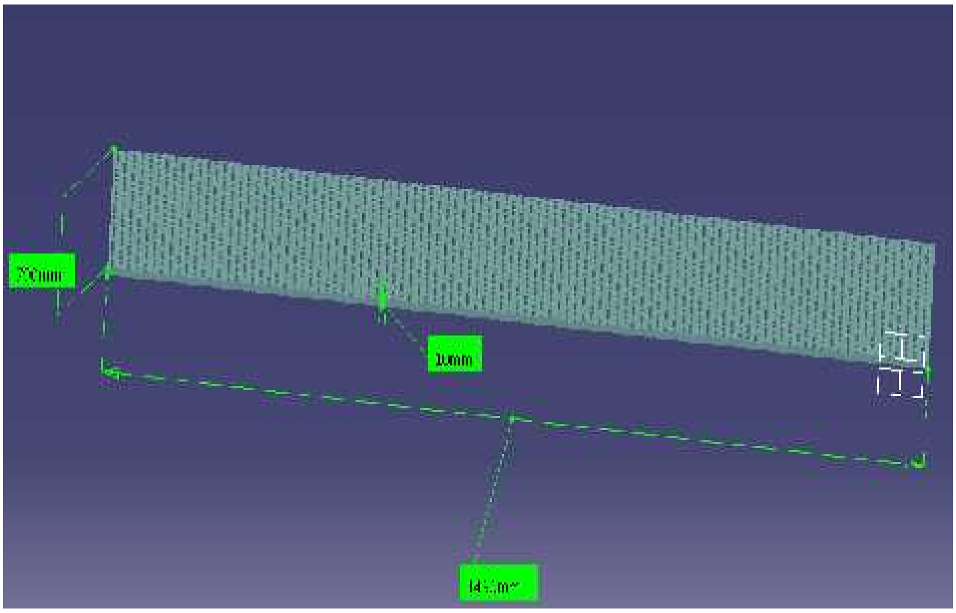


Figure4.6: Plate dimensions

And plate hole dimensions.

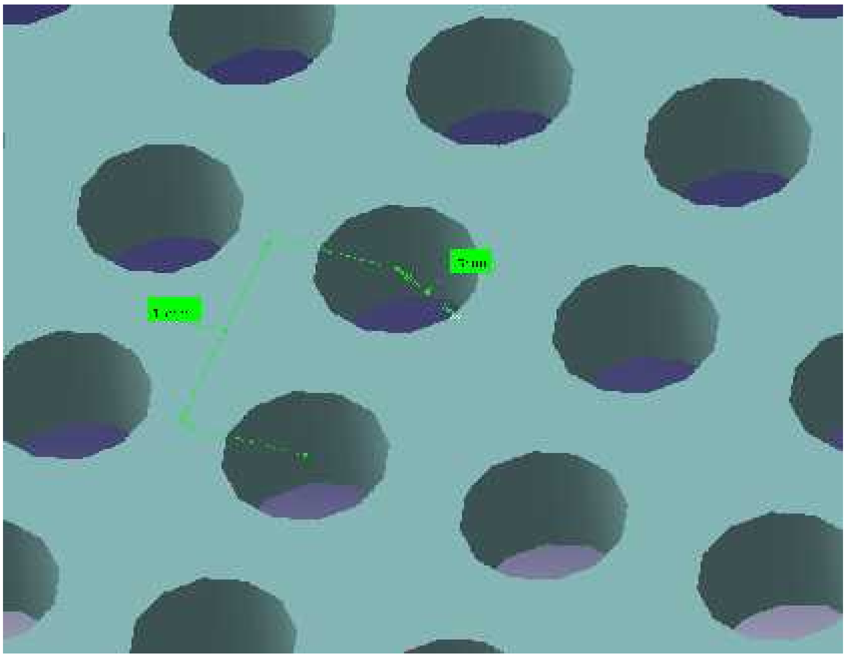


Figure 4.7: Plate hole dimensions

4.5 Pneumatic circuit.

Following are the pneumatic circuit that’s used to control the plate movement.

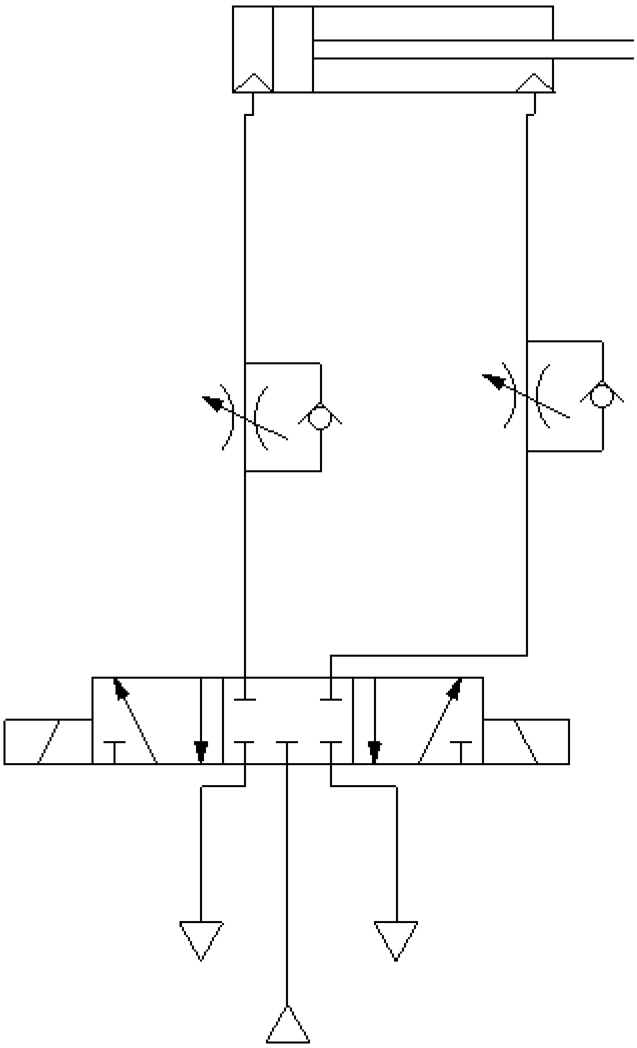


Figure 4.8: Pneumatic circuit

Chapter Five

Results and conclusion

5.1 The results.

5.2 Conclusion.

5.3 Recommendations.

5.1 The results.

After we completed the work on the prototype as planned and as previously mentioned, and after making several tests on it. We got the following results.

1-The system prevents the child from drowning in the pool.

2-The sensors detected the child.

3-The cylinder was completely fully extended after 6 seconds of receiving the signal from the controller.

4- The system sent an alarm to the people around the pool and in the home.

5-The sensors system can't differentiate between human and other things.

5.2 Conclusion.

In this project we made the required design for the implementation of the automatic rescue system in private swimming pool. We reflected the theoretical analysis and calculations that's made for typical swimming pool to a prototype.

5.3 Recommendations.

The prototype designed in this project is a primary implementation of the desired rescue idea. Many enhancements and improvements can be added to the rescue system in future graduation projects. Following are some enhancements.

1-The detection operation can be accomplished more accuracy by using image processing technology.

2-The concept can be developed to be suitable for large, public swimming pools.

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