College Of Engineering

Design A Prototype Air Conditioning Suitable For The Dome Of The Rock Mosque-Jerusalem

By

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الإهداء

إلى أمي، أمي التي ابتدأت حياتي بها، وابتدأ إنجازي بها، ويخفي الله في علم غيبه مما عملته لي أكثر بكثير مما أعلمه، فلا يوجد كلمة شكر توفيها حقها، ولا يوجد جهد يقارن بجهدها، إليكِ يا من كنتِ دائما العصا التي يتوكأ قلبي عليها، وكنتِ السند الثابت الذي لم يتزحزح رغم ميل الدنيا كلها، فلا نجاح سوى النجاح الذي تنعكس فرحته في عينيك أنتِ، ولا إنجاز سوى الإنجاز الذي يبتدأ باسمك أنتِ..

إلى بوصلة العلم والقلب، إلى الأقصى الحبيب الحبيب، إليك يا مبتدأ الطريق وإكليل نهايته، إليك نهدي هذا الجهد الضئيل، فماذا يملك الذي هو أدنى للذي هو أجل وأعلى سوى الضئيل الضئيل؟ لعل ما في قلوبنا يغفر لقلة ما بأيدينا..

إلى من باعوا أرواحهم وأعمارهم وأنفسهم في سبيل الله، إلى شهداء وأسرى وأسيرات الوطن الحبيب، إلى الشهيد يحيى عياش والشهيد رياض أبوزينة، إلى الأسيرة لمى خاطر والأسيرة دينا سعيد، ربح البيع يا من بدمائكم وأعماركم كتبتم تاريخنا وحاضرنا ومستقبلنا..

إلى أول من همس لقلبي بأن الله أكبر، إلى من رفع بي راية الإسلام منذ اللحظة الأولى فأضاء بها سبيلي وخطواتي، إلى أبي الحبيب..

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ناردين أبوزينة

بيان الخمايسه

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الملخص

تذبذب عدد المصلين داخل مسجد قبة الصخرة بين الحين والاخر يسبب مشكلة في التحكم بوحدات التهوية الموجودة داخل المسجد، حيث يهدف المشروع إلى تحسين طرق التحكم بوحدات التهوية والإنارة داخل المسجد من خلال استخدام:

NI MyRIO1900 و Programming Logic Controller (PLC).

تم تجميع البيانات المتعلقة بالمشروع (درجة الحرارة، ثاني أكسيد الكربون، الرطوبة... إلخ)، والبناء عليها لبرمجة المتحكمات باستخدام برامج:

Step7 و LabVIEW

وتم اختبار هذه البرامج بواسطة نموذج مبدئي وأثبتت قابليتها للتطبيق داخل المسجد.

تكمن أهمية المشروع بتوفير جو مناسب للمصلين خصوصا في الفترة التي يبلغ فيها الازدحام ذروته، حيث يصعب تحقيق هذا الهدف باستخدام طريقة التحكم اليدوية المستخدمة حاليا.

Abstract

The change in the worshipers number in The Dome Of The Rock mosque causes a problem in the control of the ventilation units in the mosque. so, this project aims to improve the control methods for the ventilation and lighting units inside The Dome Of The Rock mosque using Programming Logic Controller (PLC) and NI MyRIO1900.

The data which connected to our project (temperature, CO_2, humidity… etc.) had been collected, then it used to program the controllers using LabVIEW and Step7 programs, then the program is tested by a prototype and it improve its ability to implementation.

The importance of the project is represented in make the worshipers feeling comfortable inside the mosque, especially in the times when the mosque is full of people, that's because there is a difficulty of do this by the manually control method which used currently.

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Chapter One

Introduction

1.1 Introduction

The Dome Of The Rock mosque is a part of Al-Aqsa Mosque which was built in 691 AD, it was built above the rock which believes that the prophet Mohammad ascended into heaven from it.

The outside look of The Dom Of The Rock was changed over time, that's because of the earthquakes and the weather factors which affected it, so the architects rebuild some parts of it and changed its outside look in many times, for example, the golden dome was covered by lead in a period of time and by gilded aluminum in another time.

One of important changes that was the architects made it in The Dome Of The Rock is that they was covered its upper windows by gypsum and trims, that’s causes a big problem in the mosque, the airborne contaminants that is generates by the biological functions of occupants and other living organisms is rising up and don’t find a way to exit, so it's still inside and make the worshipers feels uncomfortable and effect the trims.

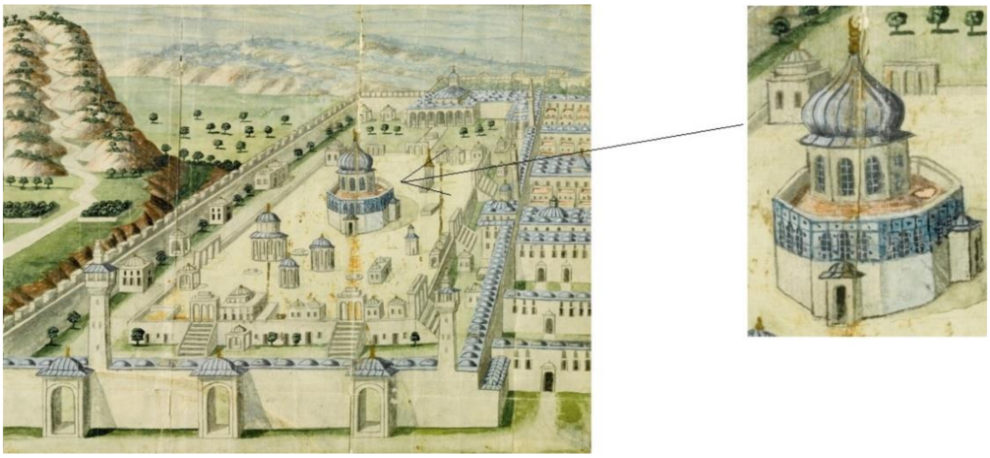

Figure 1.1: An Ottoman illustration of the al-Aqsa Mosque in Jerusalem, Palestine, 18th century.

Figure 1.2: Photo for the Dome Of The Rock now.

To solve this problem, the engineers in Al-Aqsa Mosque was provided the mosque by a ventilation units which is removal the polluted air and replace it by a fresh air, but there still have a problem of when the engineers must use this ventilation units, and when they must turn it off.

The control of lighting units is represent another problem in The Dom Of The Rock mosque, the mosque has two types of lighting units: high illumination light units and low illumination light units, its controlled through a PLC unit which depends on a program of the prayer time, that's make a problem when the mosque is full of people in any time except the prayer time.

This project use the automation techniques to improve the PLC program in Al-Aqsa mosque and make a smart lighting system, and then it will be design a prototype of ventilation and lighting control systems.

In addition, this project will be help the engineers in Al-Aqsa Mosque to controlled the ventilation remotely, through the internet Wi-Fi.

1.2 Background

This project aims to design a prototype air conditioning suitable for The Dom Of The Rock mosque, the project will be use the output that comes from the temperature, humidity, and CO_2 sensors to control the ventilation and lighting in the mosque. It aims to improve the PLC program in the PLC unit in The Dome OF The Rock.

To provide a controlled and monitored remotely for engineers working in the mosque it is possible to use the internet network, it can use to show all data from the sensor and control lighting and air conditioning, that's part of internet of things (IoT), IoT is a concept that allows objects in this project to communicate with each other.[1]

The project will be use the NI-myRIO computer to control the ventilation. In addition, it will be use the CO_2 ratio to estimate occupancy, C Brennan et al (2018) make a comparison in indirect occupancy measurement in smart building between Wireless Sensor Network (WSN) and the CO_2 ratio, to find the relationship between the CO_2 ratio and the occupancy to avoid using the smart cameras because it can be cost prohibitive, finally he was recommend using CO_2 ratio because it more efficient.[2]

The idea of use the ratio of CO_2 to control the parameters is come from the biological truth which told that all humans given a similar activity level, exhale CO_2 at a predictable rate based on occupant age and activity level, As a result, CO_2 can be used as a good indicator of human occupancy (i.e., doubling the number of people in a space will be approximately double CO_2 production).[3]

One of the first references to CO_2 measurement and ventilation was in a mechanical engineers handbook published first in 1916 by McGraw-Hill, the handbook till that the CO2 levels should not exceed 800 to 1,000 ppm[3].

The location of the sensor must avoid to be in areas near doors, air intakes or exhausts or open windows, because people breathing on the sensor limits can affect the reading, find a location where it is unlikely that people will be standing in close proximity (2 ft [0.6 m]) to the sensor.[3]

(M. Schell and D. Int-Hout, 2001) talk about the benefits of using CO_2 to control the ventilation:

1. A CO_2 control strategy can be used to maintain any per person ventilation rate. As a result this approach is highly adaptable to changing building uses and any changes that may occur in future recommended ventilation rates.
2. CO_2 DCV can provide the building owner/manager with valuable information about occupancy trends.
3. The use of CO_2 ratio to control the ventilation can reduce unnecessary over-ventilation so it reduce the power consumption.[3]

A main need for CO_2 sensor is for optimal control of indoor air quality (IAQ), where use it to reduce energy usage in ventilating & air conditioning (HVAC) systems, also the CO_2 safe when it typically < 1,000 parts per million (ppm), however prolonged exposure to a higher level of CO_2 can lead to a range of health related problems such as sick building syndrome, causing fatigue like symptoms.[4]

The engineers in Al-Aqsa Mosque try to keep the CO_2 concentration between (400-800)ppm, if the CO_2 concentration is higher than the range they turn the ventilation on.

The non-dispersive infrared (NDIR) sensors is a type of gas sensors for monitoring CO_2 concentrations in air, it the most commonly used in measuring the CO_2, because it have performance advantages in terms of long-term stability, accuracy, and power consumption for CO_2 measurement.[4]

The performance of myRIO controller is excellent and it results in a stable system, and the NI myRIO computer has onboard FPGA and microprocessor for ensure the speed of computation processes. It is equipped with a WiFi device that enables communication between devices.[5]

1.3 Problem statement

The project idea came up from the following:

- The ventilation in The Dome Of The Rock mosque hasn't a smart control system, and the increase in the CO_2 damage the inscriptions inside it in addition to health damage for visitors.
- The PLC program impractical, where must enter a prayer times for the program to illuminate the high lighting and dome lighting.
- The inability of engineers to controlled and monitored remotely for the ventilation.

1.4 Objectives

The main project objectives are to overcome the up mentioned problems as following:

- Design a smart control system for the ventilation in the dome of the rock mosque.
- Improve the PLC program in The Dome Of The Rock mosque to improve the smart lighting system, the project will be use the size of crowding in the mosque to control the lighting system.
- Use the CO_2 sensor and myrio1900 to estimate occupancy.

1.5 Overall cost

The following table show the expected cost for the project ±15%, with the composite components inside The Dome Of The Rock mosque. (See Table 1.1)

Table 1.1: Project cost table.

Item Name	No. of Item	Total Cost (NIS)
NI-Myrio-1900 unit	**1**	**3720**
Wireless Room CO2, Temperature and Humidity Sensor, model SR04-CO2-315-RH	**4**	**680**
Wireless Room CO2, Temperature Sensor, model SR04-CO2-315	**8**	**540**
Outdoor/Indoor Temperature Sensor, model AG554-ext-TRA	**2**	**80**
PLC	**1**	**11000**
Ledinaire floodlight mini 27W	**108**	**216**
CorePro LEDtube InstantFit T8 10W	**96**	**50**
LEDbulbs SceneSwitch 3W	**48**	**44**
Total cost		**52156 NIS**

1.6 Time table

The following time table shows the project introduction work divided in fifteen weeks:

Table 1.2: Time table.

weeks / Tasks	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Introduction chapter 1	■	■	■	■	■	■	■	■							
Calculations and data chapter 2				■	■	■	■	■	■	■	■	■			
System design chapter 3									■	■	■	■	■		
Conclusion chapter 4											■	■	■	■	■

2

Chapter Two

Calculations And Data

2.1 Current control methods

2.2 Data

2.3 Calculations

2.1 Current control methods

2.1.1 Ventilation

The current control method of ventilation units in The Dome Of The Rock mosque is change its operation time manually depends on the prayer time, the engineer enter the time which the ventilation must turn in it, this values changes in summer and winter. (See Figure 2.1)

This control method cause an unnecessary ventilation which consume over power, and its cause a problem in the time when the CO2 ratio increasing over 800 ppm in any time except the prayer time.

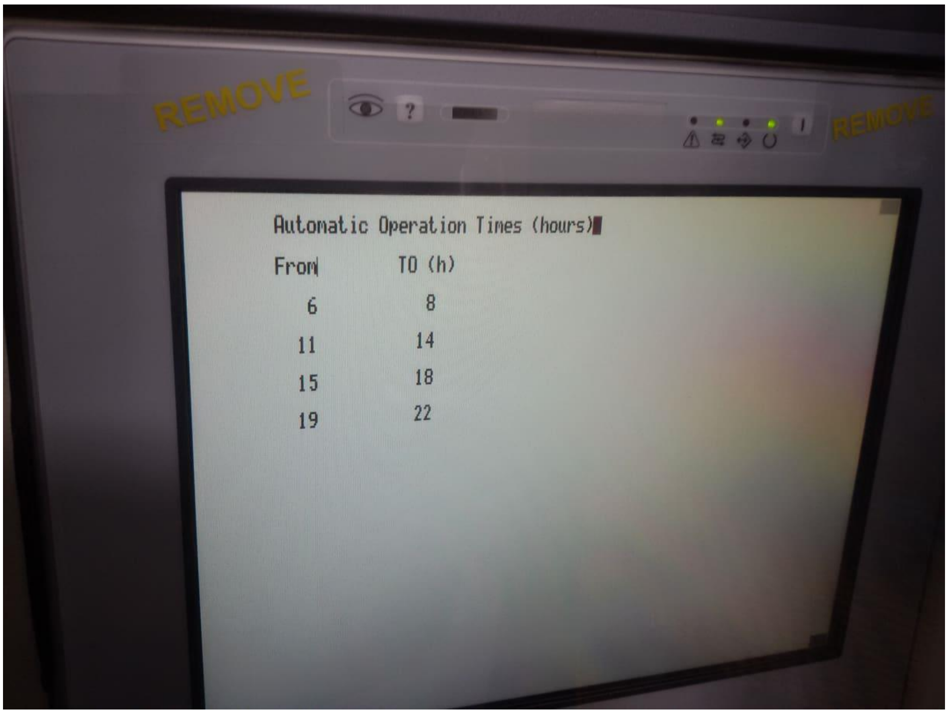

Figure 2.1: Photo for the operation time of the ventilation in the summer.

2.1.2 Lighting

The current control method of the lighting in The Dome Of The Rock mosque is using a PLC unit which depends on a program of the prayer time over the year.

The mosque have a many types of lighting units, high illumination light units, low illumination light units, chandeliers, the dome lighting and the grotto lighting.

The lighting starts from al-fajr prayer to al-esha'a prayer, in the time of al-fajr prayer the high illumination light units is turn on then between al-fajr prayer and al-duher prayer the low illumination light units is turn on, in the time of al-duher prayer the high illumination light units is turn on then between al-duher prayer and al-asr prayer the low illumination light units is turn on, , in the time of al-asr prayer the high illumination light units is turn on then between al-asr prayer and al-maghreb prayer the low illumination light units is turn on, , then from al-maghreb prayer time to al-esha'a prayer the high illumination light units still turn on.

After al-esha'a prayer all of lighting units in The Dome Of The Rock mosque is turned off, this period called close time, only the chandeliers still turned manually to help the guards if they went to turn on the lighting for any reason.

The chandeliers is turn on all the time from al-fajr prayer to al-esha'a prayer, but it can turn on manually in the close time.

The dome lighting is turn on when the high illumination units turns on and in Eid Al Fitr and Eid Al-Adha and in tourist visits.

The grotto lighting is turn on all the day except the close time.

2.2 Data

The data in this section taken from the engineering in Al-Aqsa mosque.

2.2.1 Sensors

The following table (**Table 2.1**) contain all sensors which The Dome Of The Rock mosque contain, this project will be use the sensors which the design need.

Table 2.1: Supply, install and connect the following sensors as indicated, rate includes all kind of wiring and termination needed (Type Thermokon Sensortechnik GmbH**).**

Item	Description	UNIT	Quantity
1	Outdoor Temperature and Humidity Sensor, output 2 x 0-10 Vdc supply voltage 24Vac/dc, module LC-FTA54VV	NO	**2**
2	Wireless Room CO_2, Temperature and Humidity Sensor, Requires a 24Vac/dc voltage supply, model SR04-CO_2-315-RH	NO	**4**
3	Wireless Room CO_2, Temperature Sensor, Requires a 24Vac/dc voltage supply, model SR04-CO_2-315	NO	**8**

4	Wireless Room Temperature Sensor, model SR04	NO	**4**
5	Wireless Room Temperature and Humidity Sensor	NO	**2**
6	Room VOC Sensor, including 24Vac/dc voltage supply, LW04	NO	**2**
7	Wireless Module for VOC sensor, module form 0-10Vdc to Wireless, model SR3AI	NO	**2**
8	Duct Temperature Sensor, 24Vdc voltage supply 4-20mA output, AKF10-135-TRA3	NO	**4**
9	Outdoor/Indoor Temperature Sensor, 24Vdc voltage supply 4-20mA output, to be installed in celling of the Dome, model AGS54-ext-TRA	NO	**2**
10	Wireless Modbus Receiver (Gateway), model SRC65-RS485-MODBUS	NO	**4**
11	Flow Transmitter, model DPT-Flow-2000-AZ-D	NO	**2**
12	Duct probes, model FloXact	NO	**8**
13	Differential Pressure Switch, use as a flow switch to indicate in-line fan function model PS200-B	NO	**30**
14	Power Suppliers 230Vac/24V	NO	**12**
15	Binding and Programing of wireless sensors to Gateway	NO	**1**
16	Duct Smoke Detector	NO	**5**
17	Wireless door magnet to be connected to the PLC system	NO	**2**

2.2.2 Lighting

The following table contain the type of lighting units that using in The Dome Of The Rock mosque.

Table 2.2: Type of lighting units using in The Dome Of The Rock mosque.

Class	Type	Power (W)	No.
High lighting unit	Searchlight	200	**100**
Low lighting unit	Neon T5	54	**96**
Chandeliers	Every chandeliers consist of 20 lamp	4(for each lamp)	**12**
Dome lighting	Searchlight	100	**8**

2.2.3 Ventilation

The Dome Of The Rock mosque has 48 units of ventilation, each 12 units from it connecting in the same contactor.

2.2.4 Collected data

The following tables represent the data collected for Co2, humidity and temperature sensors output inside and outside the mosque in different dates and hours, the small values is estimated by count and the big values is taken by estimation. (See Table 2.3, Table 2.4)

Table 2.3: CO_2, humidity and temperature sensors output inside the mosque.

CO2 (ppm)	Temperature (°C)	Humidity (%)	Hour	Date	Population (%)
416	15.6	45.5	08:49	4\1\2019	2.1
531	15.5	48	09:34		8.4
573	15.1	49	10:15		16.8
932	16.3	53.2	11:08		90
1055	17.7	51.7	11:03		91
956	18.5	52	11:23		90
998	18.1	47.1	11:25		90
1041	18.6	47.7	11:32		90
1151	19.1	47.5	11:40		92
1189	19.3	48.9	11:45		94
1200	19.4	49	11:47		95
1300	19.7	48.7	12:01		98
1128	19	50.2	12:15		98
1348	19.5	50.8	12:24		98
1463	20.5	50.5	12:34		100
1560	20.5	48.5	12:35		100
1378	20	48.9	12:37		100
1542	20.2	48.8	12:41		100
1541	19.5	49.5	12:56		100
1334	19	50.3	1		100
1380	19	50.2	01:02		100
454	13.2	45.9	10:26	18\2\2019	3.1
546	13.6	48.2	10:46		5.2
514	14.1	43.2	11:12		7.5
559	14	45.4	11:37		17.1
730	15.1	50.3	12:09		90
1216	14.8	54.5	12:14		93
503	16.5	49.4	11:11	19/4/2019	-
505	17.3	49.8	11:28		-
608	18.7	46.4	11:55		-

692	19.2	42.2	12:25		-
826	20.4	44.2	12:43		-

Table 2.4: CO_2, humidity and temperature sensors output outside the mosque.

CO2 (ppm)	Temperature (̊C)	Humidity (%)	Hour	Date
370	11	47	09:02	4\1\2019
452	15.2	44.2	10:20	
378	13.4	52.6	11:05	
390	19	26.3	01:08	
416	8.4	49.2	10:22	18\2\2019
403	8.1	56.2	10:48	
392	8.1	61	11:14	
382	8.3	56.8	11:39	
403	8.2	59	12:10	
303	13.6	49.2	11:09	19\4\2019
354	14.6	45.6	11:27	
382	14.8	44.6	11:54	
352	14.7	36.7	12:24	

2.2.5 Data processing

Depending on the data shown in section 2.2.4, the following curves were drown:

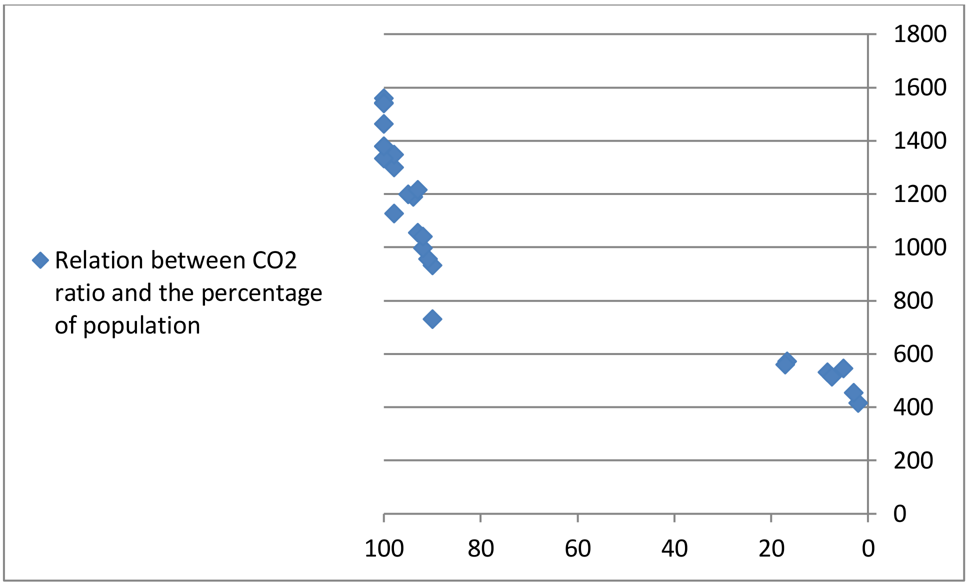

Figure 2.2: The relation between CO2 and population percentage.

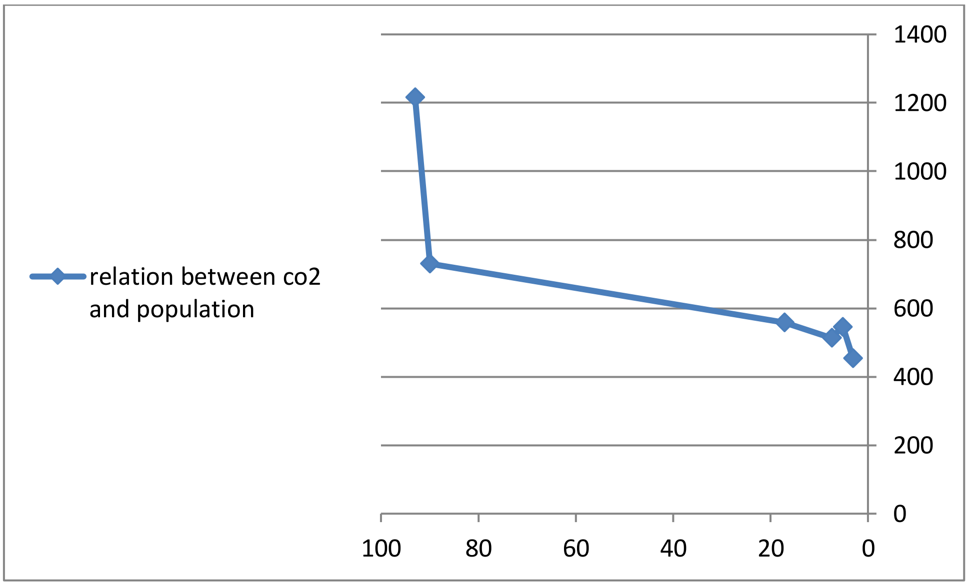

Figure 2.3: The relation between CO2 and population percentage in 18\2\2019.

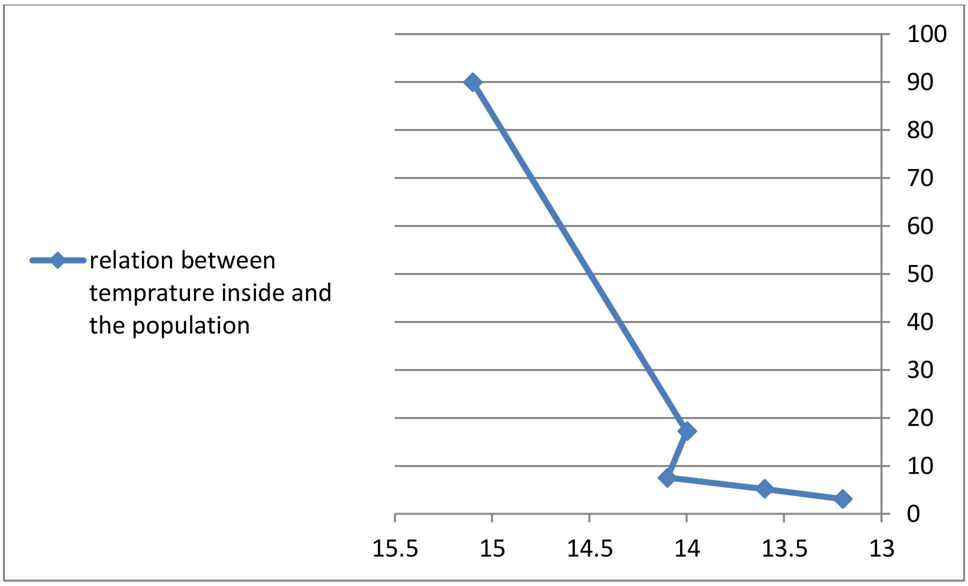

Figure 2.4: Relation between temperature inside and the population percentage.

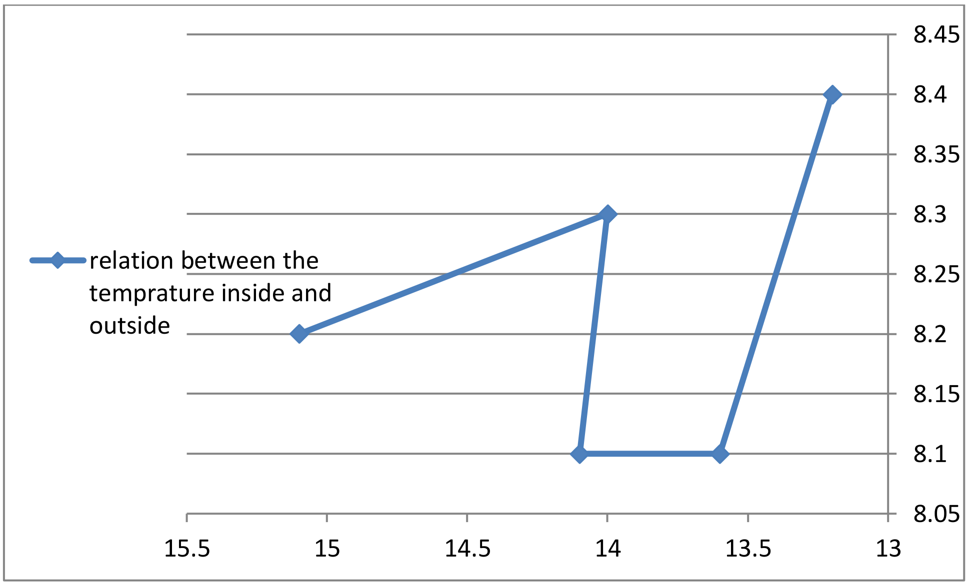

Figure 2.5: Relation between the temperature inside and outside.

Depending in the previous curves, the suitable value of the CO2 which the ventilation should turn on when the output reach to it is 700 ppm, and the range of temperature should be between 13 C° and 22 C°.

2.3 Calculations

2.3.1 Area

To estimate the size of crowding in the mosque, the area of it and the area that suitable to pray must be estimated.

The internal structure of the dome of the rock is octagon, in the center of this octagon there is a circle which is not suitable for prayer. (See Figure 2.2)

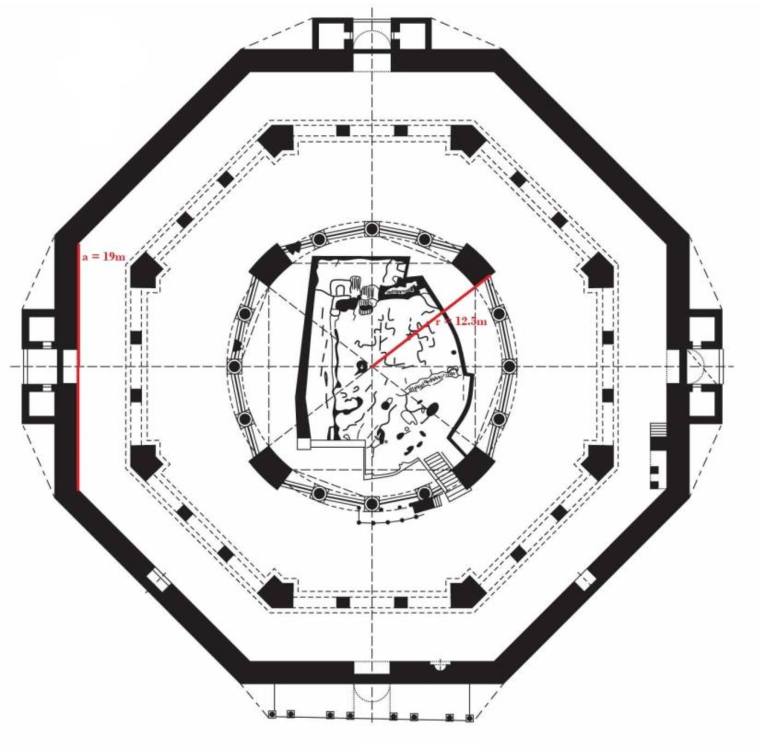

Figure 2.6: Sketch for The Dome Of The Rock mosque.

So the area that suitable to pray in the dome of the rock is:

$$A_{\text{That suitable to pray}} = A_{\text{octagon}} - A_{\text{circle}} \quad \textbf{(2.1)}$$

$$A_{\text{octagon}} = 4.828427 * a^2 \quad \textbf{(2.2)}$$

where **a:** is the side length of the octagon and it equal 19m.[6]

$$A_{\text{octagon}} = 1743.062147 \text{ m}^2$$

$A_{circle} = \pi * r^2$ **(2.3)**

where **r**: is the radius of the circle and it equal 12.5m.[6]

$A_{circle} = 490.625\ m^2$

So, from equation (2.1):

$\mathbf{A_{That\ suitable\ to\ pray} = 1252.437147\ m^2}$

2.3.2 Lighting distribution

All the lighting units in The Dome Of The Rock mosque is indirect lighting except of the chandeliers which is a direct lighting, so the mosque -at indirect lighting- has a benefit approximately 22% from illumination. According to the Egyptian code, the direct luminous flux (Φ) which required in the low lighting unit and chandeliers are 350 lumen approximately and in high lighting unit and dome lighting are 550 lumen approximately.[6]

The Illumination equation (for direct lighting): $E = \frac{\Phi}{A}$ **(2.4)**

The Illumination equation (for indirect lighting): $E = \frac{\Phi}{A} * 0.22$ **(2.5)**

A: Total area of the mosque (m^2).

Φ: Luminous Flux (lumen).

This project chose the LED lighting because of the advantage of LED's such as high efficiency (lumen/watt), high life time up to 50,000hr, dimmable, low temperature, different colors, no maintenance and low power.[7]

2.3.2.1 Low lighting

At low lighting it will be used the CorePro LEDtube InstantFit T8 instead of the neon T5. From the datasheet of the LED tube T8:

Φ = 1600 lumen for one unit, then

$E_{\text{total at indirect lighting}} = \frac{1600*96\ lm}{1743.062\ m^2} * 0.22$ = 19.38657 lux

At luminous flux direct (350lm) from the Egyptian code:

$E_{\text{requered depending on the egyption code}} = \frac{300*96\ lm}{1743.062\ m^2}$ = 19.276 lux

Then the LED tube T8 is appropriate choice in this project.

The neon T5 which currently used in the Dome Of The Rock mosque is consumed power equal 54W for one unit, but when it replaced by the LED tube T8 the power that will be consumed equal 10W for one unit.

2.3.2.2 High lighting

At high lighting it will be used the Ledinaire floodlight mini instead of the searchlights. From the datasheet of the Ledinaire floodlight mini:

Φ = 2500 lumen for one unit, then

$E_{\text{total at indirect lighting}} = \frac{2500*100\ lm}{1743.062\ m^2} * 0.22$ = 31.5536 lux

At luminous flux direct (550 lm) from the Egyptian code:

$E_{\text{trequered depending on the egyption code}} = \frac{550*100\ lm}{1743.062\ m^2}$ = 31.5536 lux

Then the Ledinaire floodlight mini is appropriate choice in this project.

The searchlights which currently used in the Dome Of The Rock mosque is consumed power equal 200W for one unit, but when it replaced by Ledinaire floodlight mini the power that will consumed equal 27W for one unit.

2.3.2.3 Dome lighting

At dome lighting it will be used the Ledinaire floodlight mini instead of the searchlights like the high lighting, but the different between the both is that the dome searchlight which currently used in the Dome Of The Rock mosque is consumed power equal 100W for one unit.

2.3.2.4 Chandeliers

At chandeliers it will be used the LED bulbs instead of the searchlights. From the datasheet of the LED bulbs:

Φ = 320 lumen for one unit, then

$$E_{\text{total at direct lighting}} = \frac{320*12*4\ lm}{1743.062\ m^2} = 8.8 \text{ lux}$$

Then the LED bulbs is appropriate choice in this project, where the chandeliers is direct lighting in the mosque.

The chandeliers which currently used in the Dome Of The Rock mosque is consumed power equal 4W for one unit, but when it replaced by the LED bulbs the power consumed will be equal to 3W for one unit from.

Table (2.5) explain currently consumed power and the consume power for the units choose in this project -new consume power-. The power equal number of units multiply by the power for one unit. Then difference between them is the power will be saved in this project.

Table 2.5 : The total power which will be saved in the mosque.

Type of lighting	**Number of units**	**Currently consumed power (W)**	**New consume power (W)**	**Saved Power (W)**
High lighting	100	20000	2700	17300
Low lighting	96	5184	960	4224
Dome lighting	8	800	216	584
Chandeliers	12*4	192	720	528
Total power that will be saved				22636 W

Depending on the previous table:

$$E = P * t \qquad \textbf{(2.6)}$$

Where:

- E: Energy (Joule)
- P: Power (Watt)
- T: Operation time (Hour)

E (for one day) = 17.3*5+ 4.2*12+ 0.58*5+ 0.5*12= 145.8 K Joule

The money saving in one month= E * 30 * price **(2.7)**

= 145.8 * 30 * 0.69 = 3018.06 NIS\ month

3

Chapter Three

System Design And Programming

3.1 General block diagram

3.2 Ventilation control system

3.3 Lighting control system

3.1 General block diagram

Based on the component which this project will use, this is the block diagram for the prototype and the project.

3.1.1 Project block diagram

The general block diagram for the project is shown in the following figure:

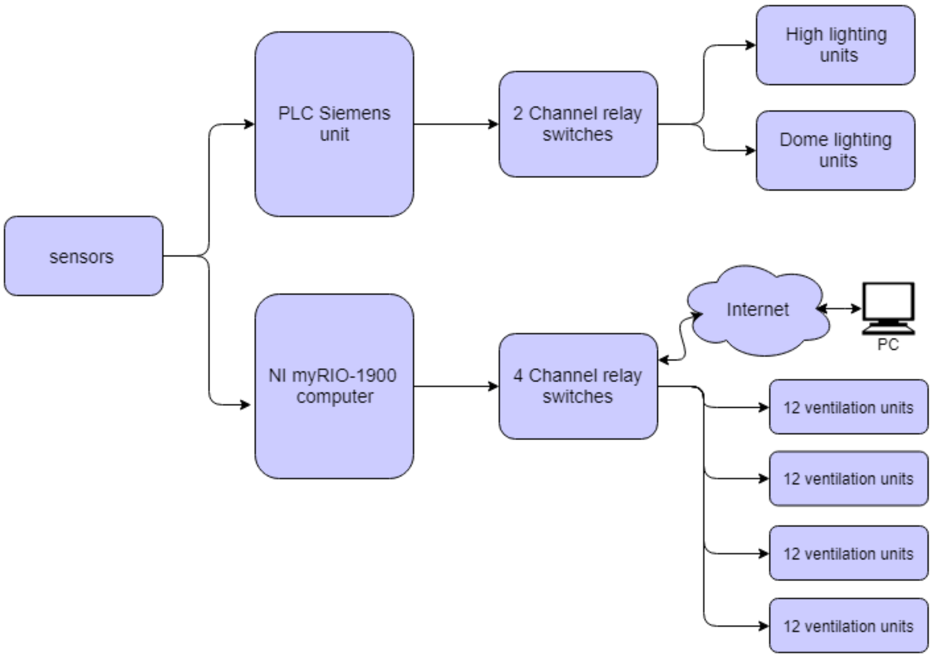

Figure 3.1: General block diagram for the project.

3.1.2 Prototype block diagram

The general block diagram for the prototype is shown in the following figure:

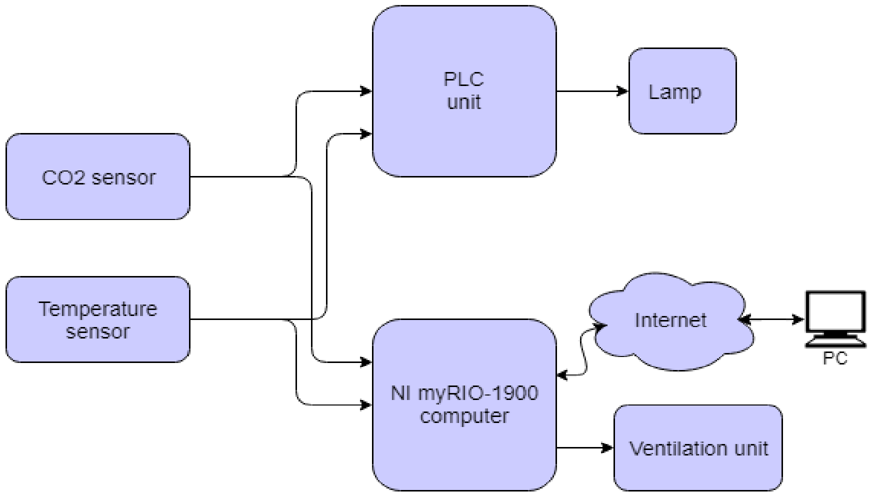

Figure 3.2: General block diagram for the prototype.

3.2 Ventilation control system

3.2.1 Introduction

Due to the disadvantages of the current control method of the ventilation units which was mentioned in the previous chapters, this project will be find another method to control the ventilation using the NI myRIO.

In the ventilation control system, the output that comes from the CO2 and temperature sensors used as an input for NI myRIO, then the myRIO will be use this inputs to control the ventilation.

The sensors in the Dome Of The Rock mosque was placed in two places:

1. In the height of two meters from the ground.
2. Two meters down from the roof.

when the people breath, the rotten air rise up and make a balloon in the top, the sensors which placed two meter down from the roof will feel this change in the air, then depends on the output of the sensors, NI myRIO will choose the suitable time to turn the ventilation units on when the balloon reaches to the sensors which placed in the height of two meters from the ground.

This project design a manual control method for the system to use it when the ventilation need a maintenance and special cases such as changing the air inside the mosque.

3.2.2 Block diagram

The control done by receiving commands from sensors or manual to NI myRIO, then it send digital signal to turning on the ventilation or turning it off.

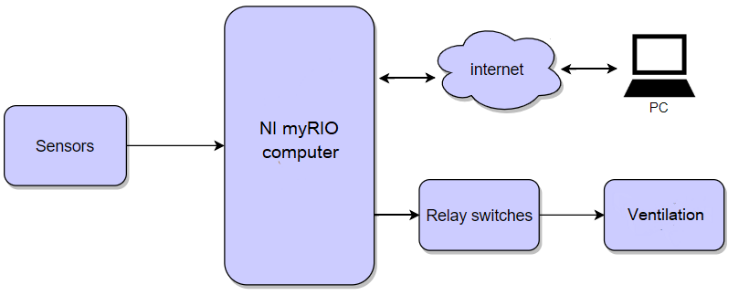

Figure 3.3: Block diagram for ventilation system.

3.2.3 Required component

This project will be use the components which the design needs, and considering which The Dome Of The Rock mosque contain.

The component which will be used:

- **Ventilation**

The number of ventilation units in The Dome Of The Rock mosque is 48 from S&P company and its model is TD1300 silent.

TD1300 is a low profile “Mixed-flow” fans with sound absorbent insulation. Extremely quiet. Manufactured in plastic material, with a specifically designed internal skin to direct the sound waves at the right angle for them to be captured by the sound-absorbent material. Fitted with rubber gaskets on the inlet and outlet to absorb vibrations, a body that can be dismantled. Connection box can be rotated 360º, to facilitate easy connection of the power cable.

Motors speed controllable 230V-50Hz motor.[8]

Figure 3.4: TD 13000 silent unit.

- **Sensors**

From all the sensors which the mosque contain, this project will use the following sensors:

1. Wireless Room CO_2, Temperature and Humidity Sensor, model SR04-CO_2-315-RH, and the number of it is 4.
2. Wireless Room CO_2, Temperature Sensor, model SR04-CO_2-315, and the number of it is 8.
3. Outdoor/Indoor Temperature Sensor, model AG 554-ext-TRA, and the number of it is 2.

Figuer3.5: model SR04-CO_2-315.

Figuer3.6: Temperature Sensor (model AGS 54-ext-TRA).

- **Processing unit (National Instruments myRIO 1900)**

This project need to use 10 analog input (CO_2, humidity and temperature sensors) to control the ventilation.

So, the control system needs 10 analog input and 4 digital output, so the NI myRIO 1900 appropriate for the design.

The word (RIO) stands for Reconfigurable Input Output, NI myRIO which is thereby a combination of dual core ARM Cortex-A9 processor with 667 MHz frequency speed, and FPGA type a Xilinx Z-7010 embedded on it, the analog and digital input/outputs are interfaced through FPGA in NI myRIO, while most of the mathematical calculations, including the feedback and feed forward loops, are performed by the CPU. In addition, it has Integrated WiFi, analog I/O ports and digital I/O ports and many others, and the NI myRIO has produce 5V dc supply (See Figure 3.4).

Figure 3.7: NI myRIO computer.

There are several ways to exchange data between the FPGA and the CPU. In this project, the FPGA reads the measurements from analog input, performs some preprocessing and scaling on the data and then passes the data to the CPU, then the control process is performed inside the CPU connecting multiple objects in a smart system.

Implementation of the control system on NI myRIO will be do through National Instruments LabVIEW software environment, then upload the code on the NI myRIO computer until using it without personal computer installed with LabVIEW.

- **4 Channel relay switches module.**

In this control system, relay serves as a connector and breaker voltage of the ventilation, it work at NI myRIO computer voltage (5V) and give 220V to run the ventilation**.**

Figure 3.8: 4 Channel relay switches module.

3.2.4 Programming

Depending on the result that given from the data and curves in chapter 2, the ventilation control system was designed due to the following specifications:

1. The ventilation units has two operation modes (manual or automatic) which represent the status of switch(Automatic\ Manual), when the switch=0 the mode is manual and when the switch equal 1 the mode is manual.
2. In automatic mode the ventilation units turn on when four from the eight CO_2 sensors is given output equal or greater than 700 ppm, and the temperature between 13C° and 22C°.

3. In automatic mode, if the temperature is greater than 22C° or less than 13C° the ventilation will be turned off, but to make a priority to the CO_2 sensors it will be taken to consider that the CO_2 sensors output is less than 800 ppm.
4. In manual mode the ventilation turn on and off according to the state of the switch (Manual on\off), if it equal 1 the ventilation turn on and if it equal to zero the ventilation turned off.
5. When the ventilation is turned on it will turn for 30 minutes minimum , after 30 minutes if the CO_2 is still more than 700 ppm, the ventilation will still on, and if it be less than 700 ppm , the ventilation units will turn off.
6. There is three possible errors may be in the sensors:
   1. out of calibration
   2. damage
   3. disconnection

   In this three cases the sensors will give values out of range or it won't give a value, so in error2 the project check if the output of the sensors is in the range of 100 ppm and 2550 ppm for CO_2 sensor, and between 0C° and 40C° for temperature sensors, if the sensors is out of range the led will turn on.

7. The code is attached in appendix C and flowchart is shown in the following figure.

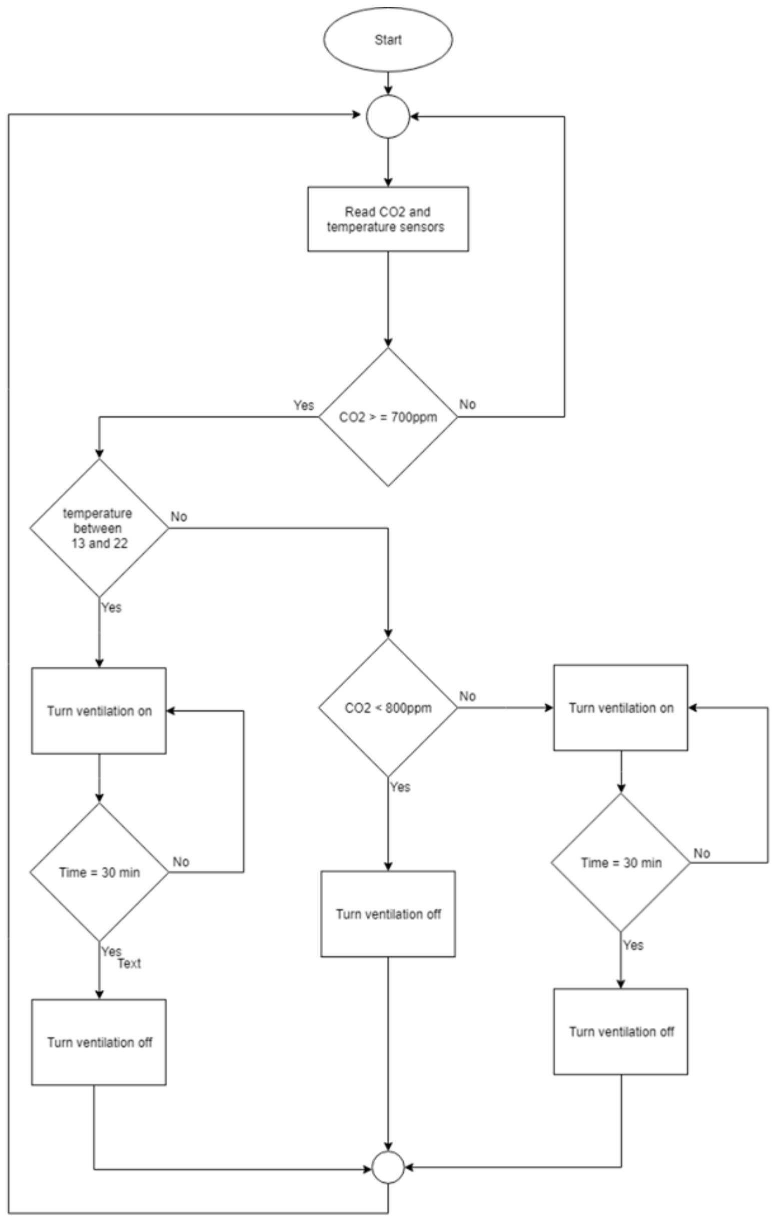

Figure 3.9: Flowchart for the ventilation programming.

The code is written used 2 Laboratory Virtual Instrument Engineering Workbench (LabVIEW), LabVIEW is systems engineering software for applications that require test, measurement, and control with rapid access to hardware and data insights. LabVIEW offers a graphical programming approach that helps you visualize every aspect of your application, including hardware configuration, measurement data, and debugging.[10]

LabVIEW is commonly used for data acquisition, instrument control, and industrial automation on a variety of operating systems.

It has many benefits, for example it includes extensive support for interfacing to devices instruments, camera, and other devices, also it have many libraries with a large number of functions for data acquisition, signal generation, mathematics, statistics, signal conditioning, analysis, etc.

Using LabVIEW, it is very easy to program multiple tasks that are performed in parallel. For example, this is done easily by drawing two or more parallel while loops and connecting them to two separate nodes. This is a great benefit for test system automation, where it is common practice to run processes like test sequencing, data recording, and hardware interfacing in parallel.

This project used LabVIEW to write the code for NI myRIO computer, the code shown in appendix

3.3 Lighting control system

3.3.1 Introduction

Due to the disadvantages of the current control method of the lighting units which was mentioned in the previous chapters, this project will be improve the PLC program in the Dome Of The Rock to control the high lighting units and dome lighting units to turn it on automatically in every time when the mosque full of people in any time other than prayer times.

The high lighting units and dome lighting units will be turn on in the prayer times and when the mosque is full of people, the size of crowding will be estimated depends on the sensors output, which depends on the maximum number of people that the mosque can contain.

3.3.2 Block diagram

The operation done by receiving commands from sensors to PLC unit, then the PLC unit send digital signal to relay switches to turning on the lighting units or turning it off.

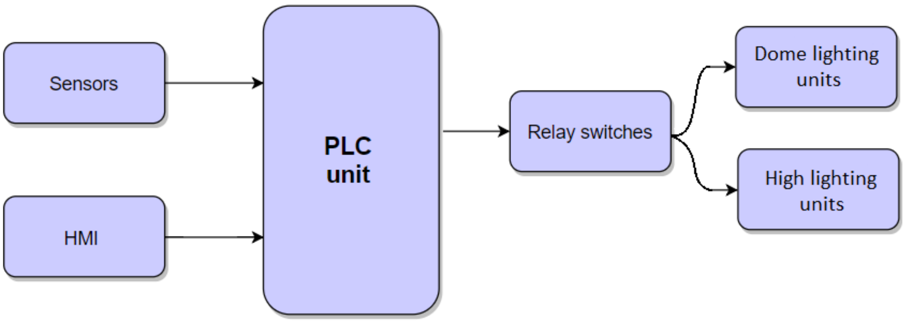

Figure 3.10: Block diagram for lighting control system.

3.3.3 Required component

The component which will be used:

- **PLC unit**

The PLC Siemens SIMATIC S7-1500 unit is using in Al-Aqsa mosque to control the lighting units.

Figure 3.11: PLC Siemens unit.

- **Sensors**

This part will be use the following sensors:

1. Wireless Room CO_2, Temperature and Humidity Sensor, model SR04-CO_2-315-RH, and the number of it is 4.
2. Wireless Room CO_2, Temperature Sensor, model SR04-CO_2-315, and the number of it is 8. (see Figure 3.2)

The indoor CO_2 and temperature sensors used to measure the ratio of CO_2 inside the mosque, when the ratio exceed a specific range that's an indicator of high size of crowding in the mosque and will be need to turn the high lighting on.

- **2 Channel relay switches module.**

In this control system, relay serves as a connector and breaker voltage of the lighting units, it take the PLC voltage (5V) and give 220V to run the lighting units**.**

This project will use two channel relay switches to connect it with two output (high lighting units and dome lighting units).

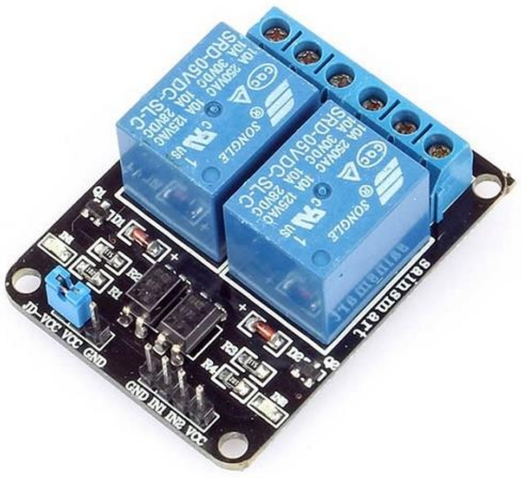

Figure 3.12: Two channel relay switches module.

- **High Lighting units and dome lighting units**

As was mentioned in the previous chapter, the type of high lighting and dome lighting using in The Dome Of The Rock mosque is searchlight.

Figure 3.13: The searchlight in The Dome Of The Rock mosque.

3.3.4 Programming

Depending on the result that given from the data and curves in chapter 2, the lighting control system was designed due to the following specifications:

1. The lighting control will be done through the previous program connected in OR gate with the project new addition.
2. The lighting depending on the CO_2 sensors only which give us a good indicator for the number of people in the mosque.
3. The high illumination lighting units will turn on if two of four of CO_2 sensors give output more than 765 ppm.
4. The units will turn on for 40 minutes minimum, after that if the CO_2 still greater than 700 the high lighting units will still on.
5. The code attached in appendix D and flowchart is shown in the following figure.

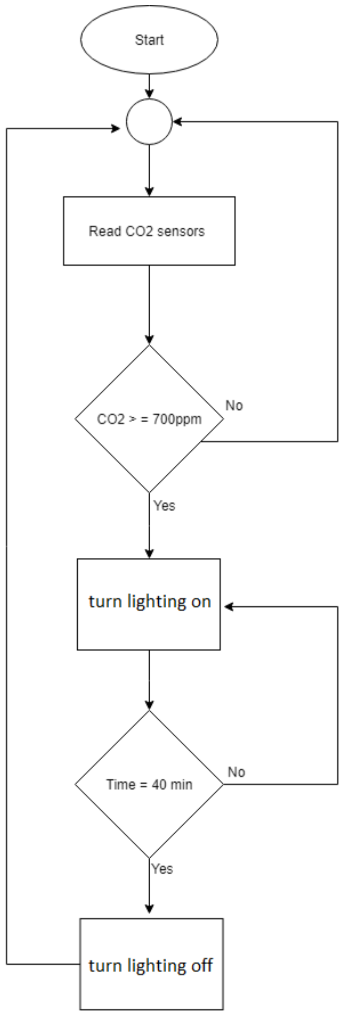

Figure 3.14: Flowchart for the lighting control system**.**

The code written used SIMATIC STEP 7 Basic (TIA Portal), STEP 7 is the standard software package used for configuring and programming SIMATIC programmable logic controllers (PLC).

Its provides the possibility to write programs in three programming languages: Ladder Logic, Statement List and Function Block Diagram.

This project will use this program to modify the PLC program in the mosque. Then will be use STEP7 to improve the PLC code.

4

Chapter Four

Results And Conclusion

4.1 Results

4.2 Conclusion

4.3 Prototype cost

4.4 Recommendation

4.1 Results

The following table contains the result. (See Table 4.1)

Table 4.1: Project results.

Operation Name	Before	After
Ventilation	Traditional control	NI- MyRIO control
Lighting	Prayer time depending control	Population depending control
Saving lighting power	Without saving	Saving 22.636 KW
Operation for the ventilation units	Manual	Automatic\manual
Entry\ Input	Manual (prayer time)	CO2 and temperature sensors
Saving money	Without saving	Save 3018.06 NIS monthly

4.2 Conclusion

The conclusions from the project are:

1. There is a delay must be found between the time that the ventilation turned on in it and the time that the lighting turned on in it when you control the both using CO2 sensors, that to be sure that the population is decrease.

2. Change the type of the lighting units that is used in a specific place may save a lot of many.

3. The lighting units must have periodic cleaning to have higher efficiency.

4. CO_2 sensors give a good indicator for the number of people in a specific place.

5. Ventilation units can be a good solution to solve the problem of air quality in the closed places.

4.3 Prototype cost

The following table shows the cost for the prototype ±15%. (See Table 4.1)

Table 4.1: Prototype Cost Table.

Item Name	No. of Item	Total Cost (NIS)
NI-Myrio-1900 unit	**1**	**2040**
PLC Siemens unit	**1**	**500**
Gas sensor (QM-9)	**1**	**35**
Temperature sensor (LM35)	**1**	**5**
Small fan	**1**	**4**
Lamp	**1**	**4**
Total Cost		**2588 NIS**

4.4 Recommendation

If any future projects consider adding modifications for the same project we recommend the following:

1. Replacing the current units of lighting, and installation the units which this project recommended it.
2. Adding the:

    a. Heating and Cooling HVAC System.

    b. Adding dehumidifier device to reduces and maintains the level of humidity in the air, thus providing additional protection for inscriptions inside the mosque.

    c. Adding air purifier or air cleaner is a device which removes contaminants from the air.

   Then connect these devices to the smart control system inside the mosque.

3. Change the language of project to Arabic.

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[10] https://www. ni.com, Date:7\12\2018.

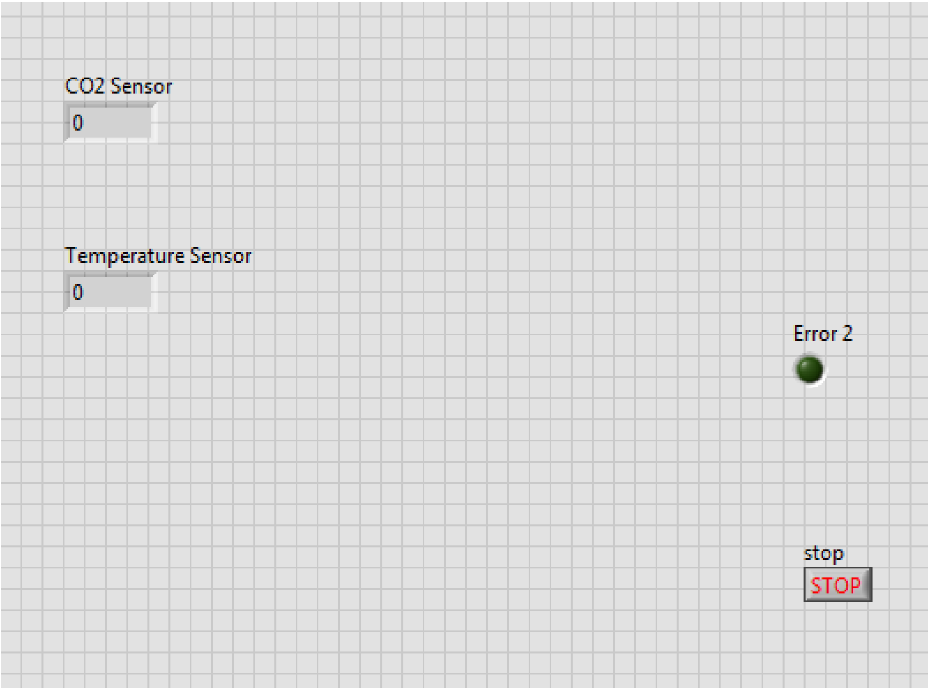
Appendix A

The Prototype

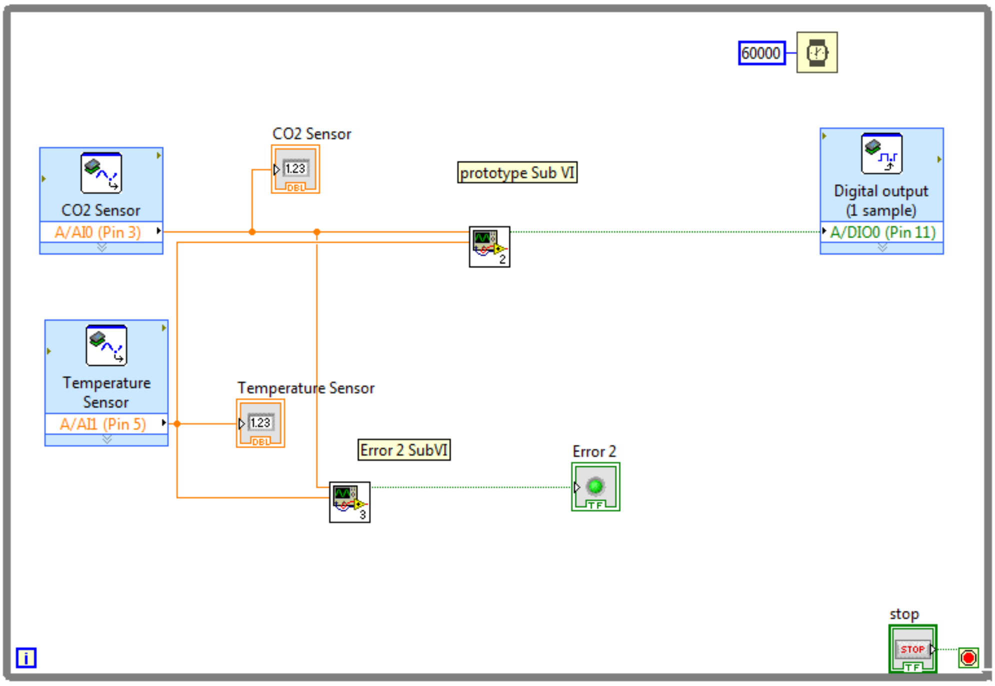
The project design is a prototype for bigger project to control the ventilation in the Dome Of The Rock mosque.

The prototype for control the ventilation was used the gas sensor MQ-9 instead of CO_2 gas sensor, because that is a difficulty to change the output of CO_2 sensor.

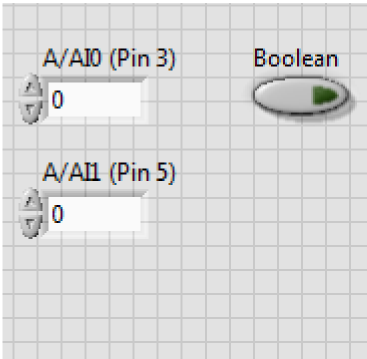
Code of the prototype



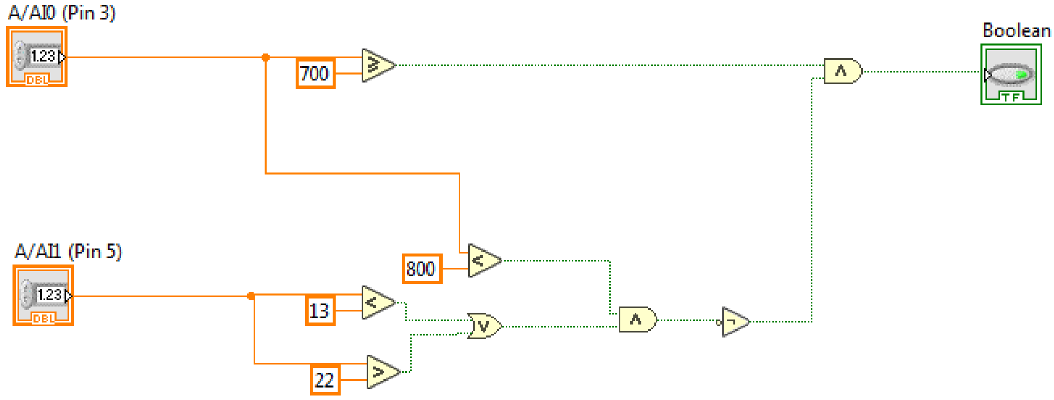
Figuer A.1: Front Panel for the prototype.



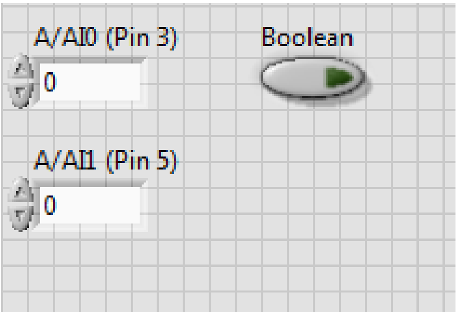
Figuer A.2: Block Diagram for the prototype.



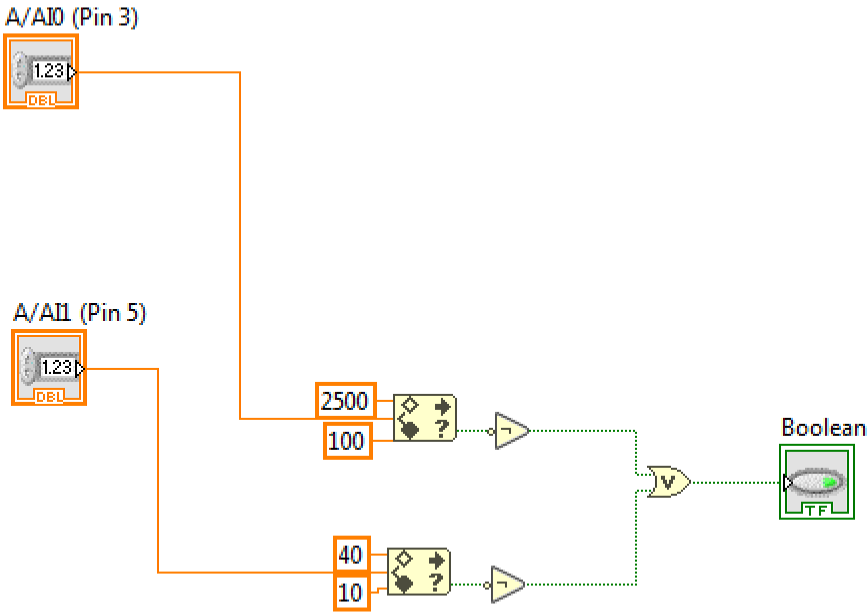
Figuer A.3: Front Panel for prototype Sub VI.



Figuer A.4: Block Diagram for prototype Sub VI.

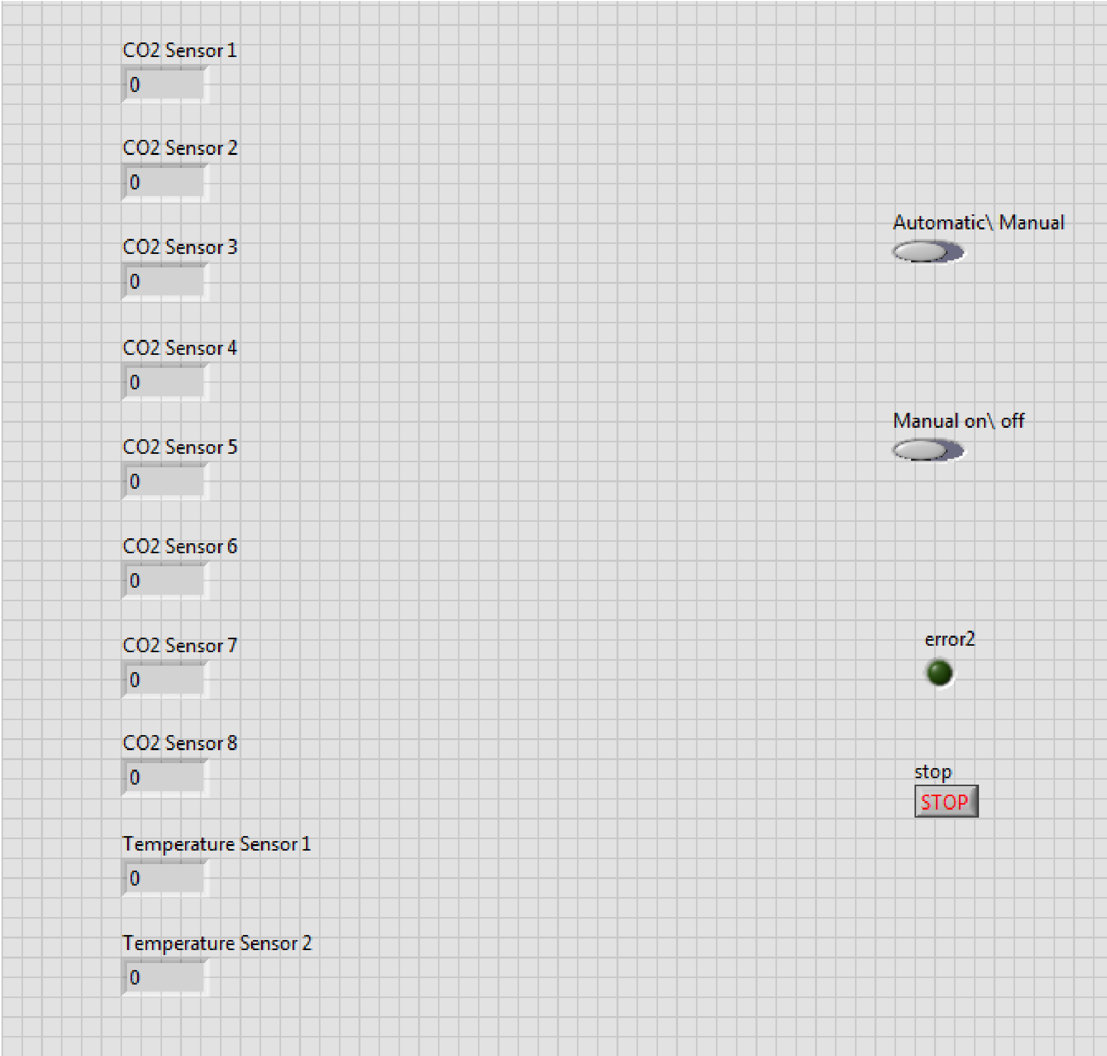


Figuer A.5: Front Panel for error2 Sub VI.

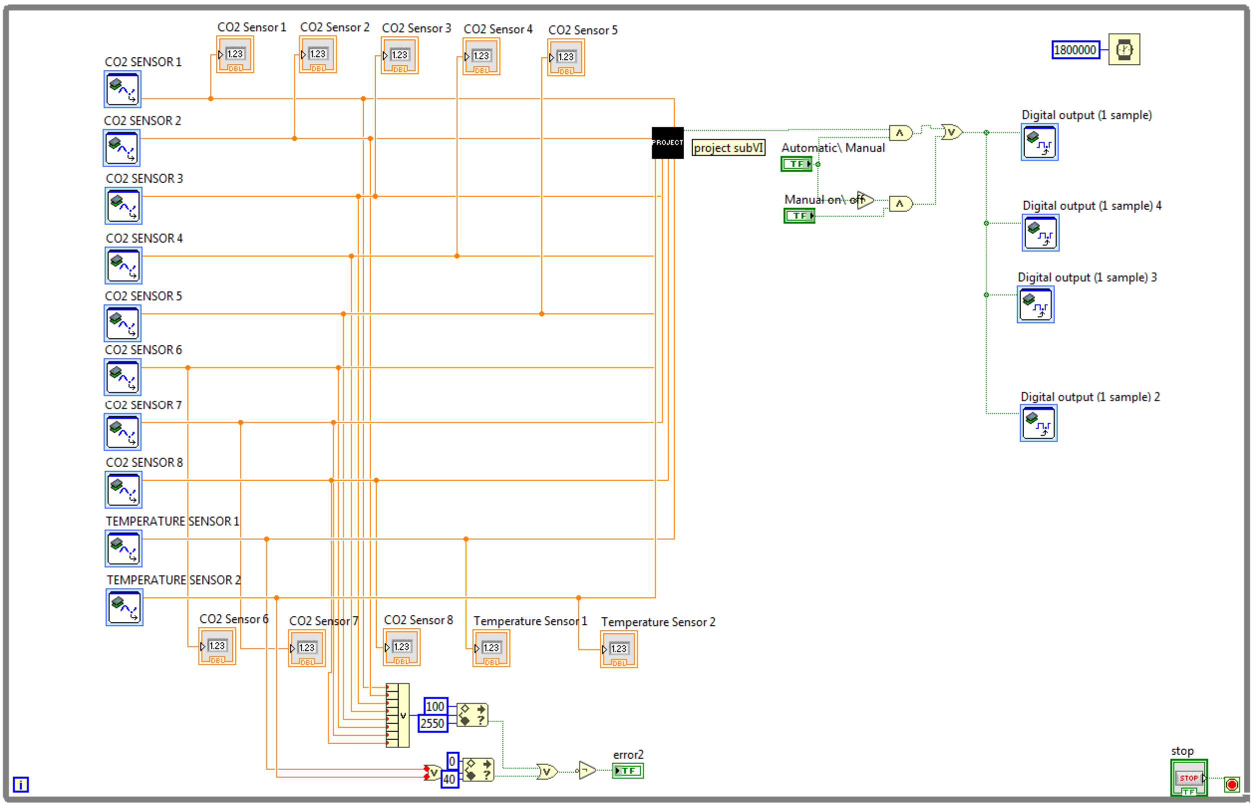


Figuer A.5: Block Diagram for error2 SubVI.

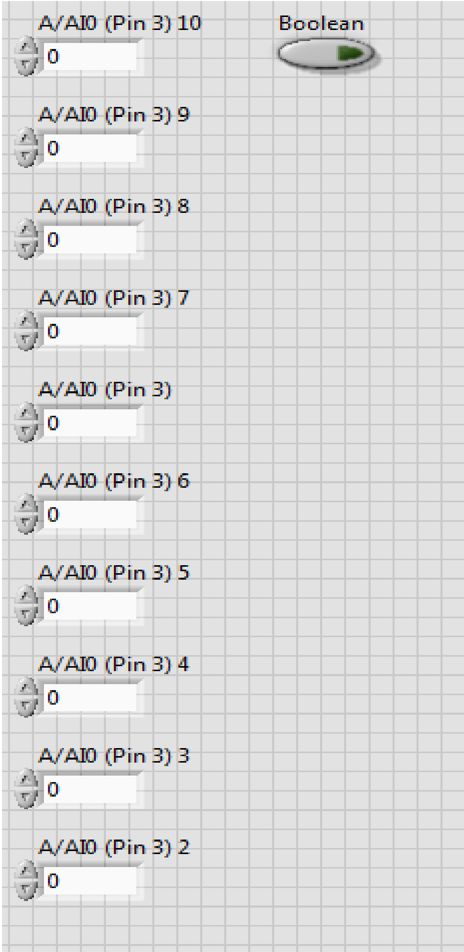
Code of the project



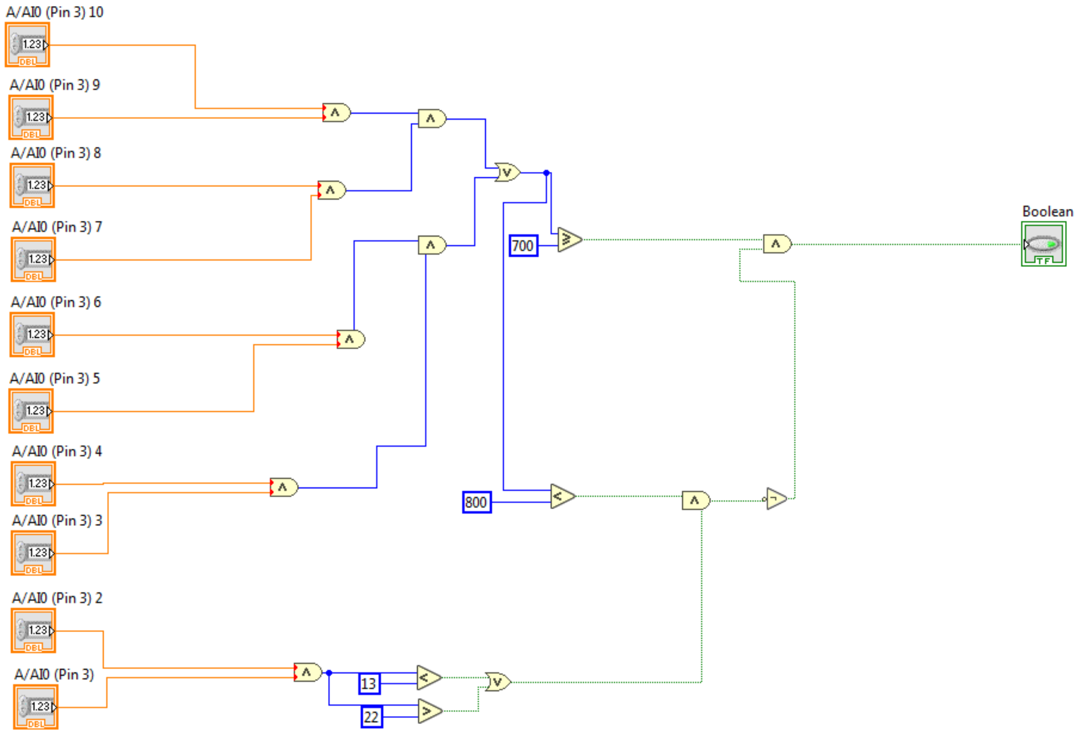
Figuer A.6: Front Panel for the project.



Figuer A.7: Block Diagram for the project.

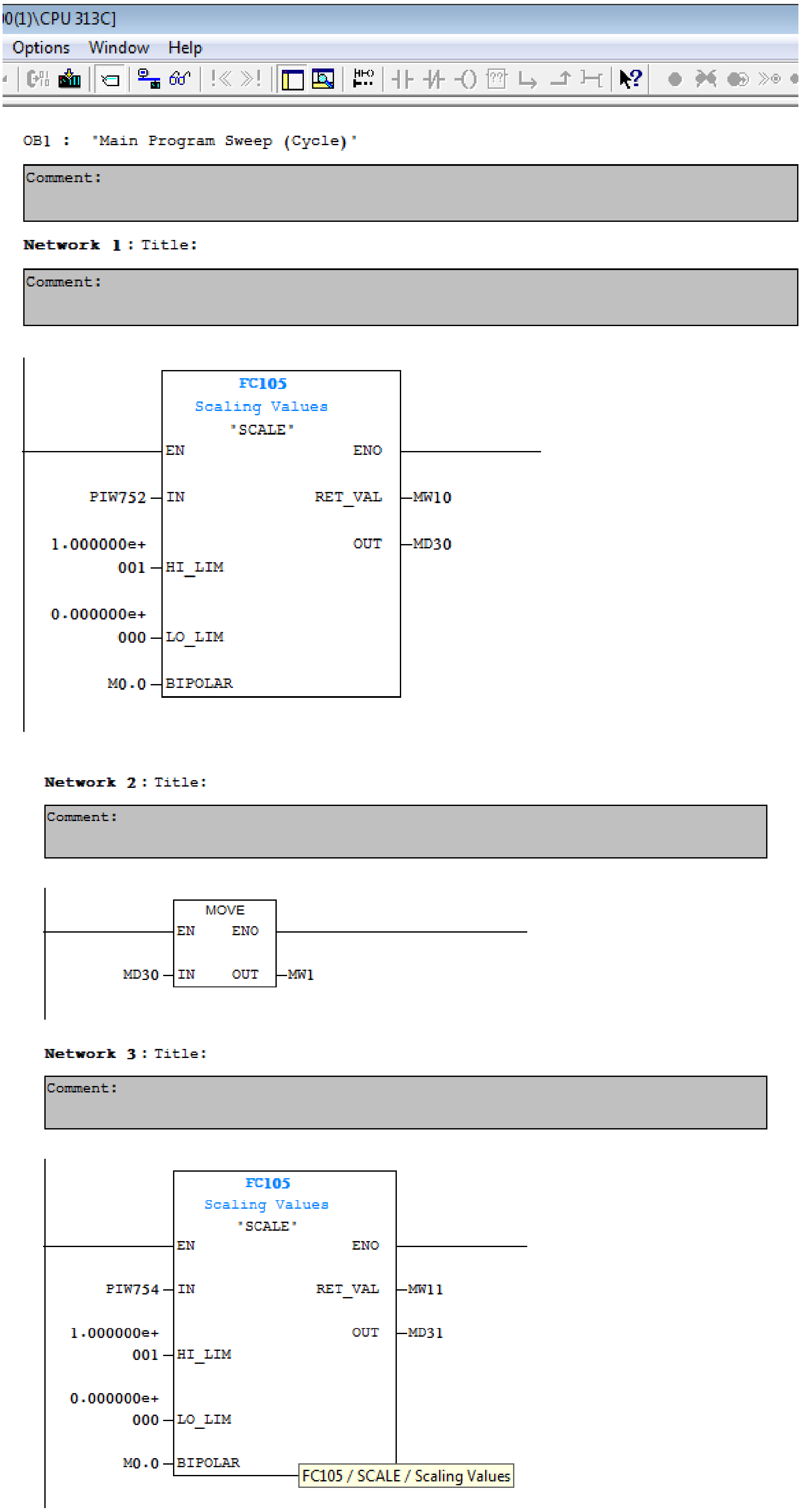


Figuer A.8: Front Panel for the project SubVI.



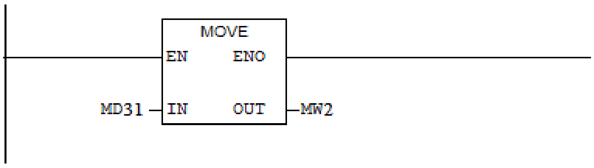
Figuer A.9: Block Diagram for the project SubVI.

Lighting PLC Program



Network 4 : Title:

Comment:



Network 5 : Title:

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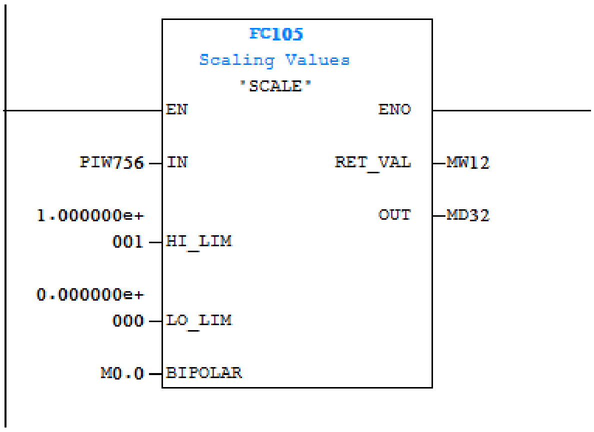
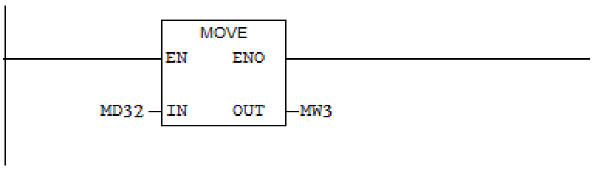


Network 6 : Title:

Comment:



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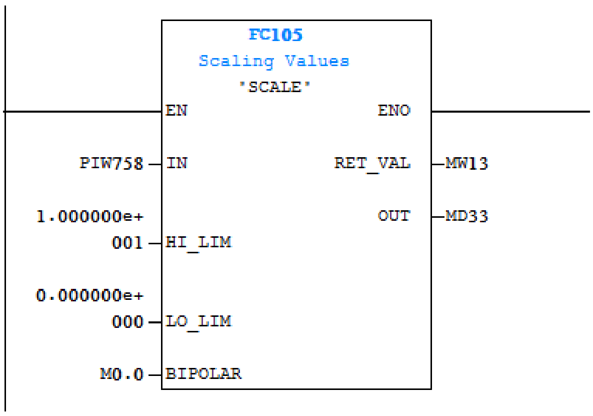
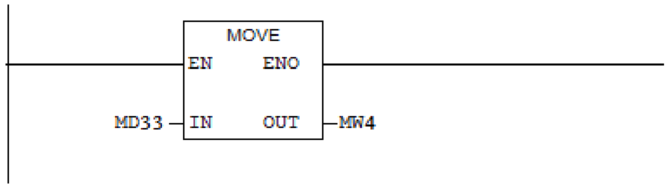


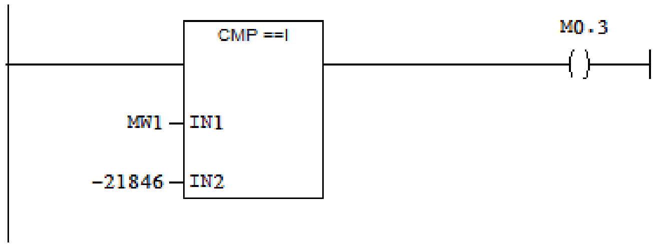
Network 8 : Title:

Comment:



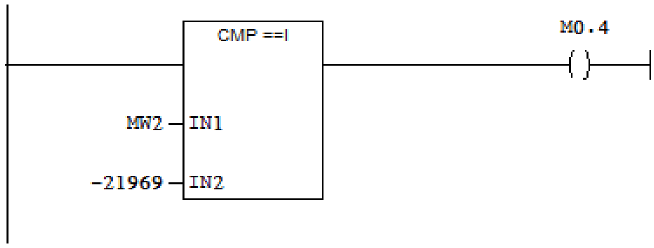
Network 9 : Title:

Comment:



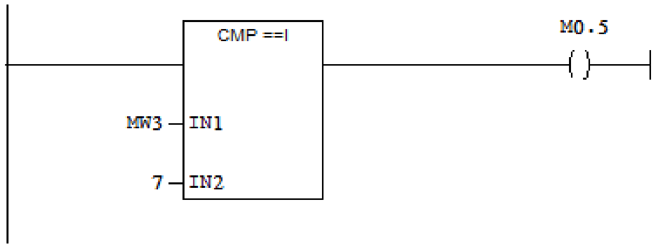
Network 10 : Title:

Comment:



Network 11 : Title:

Comment:



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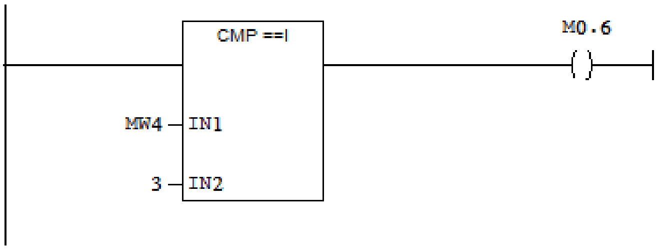
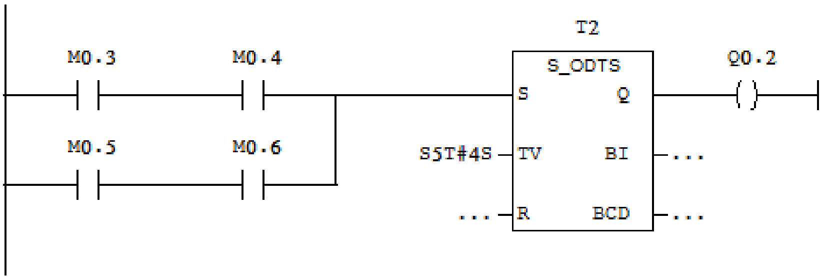
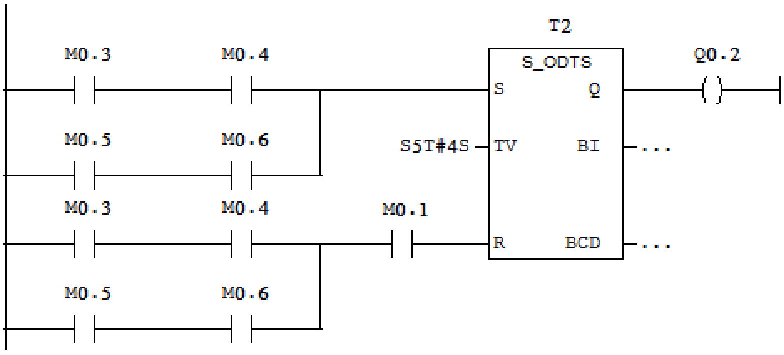


Network 13 : Title:

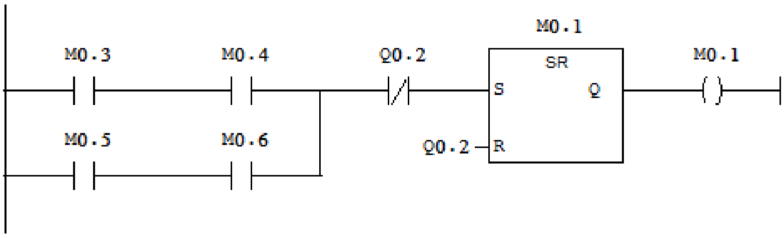
Comment:





Network 14 : Title:

Comment:



Network 15 : Title:

Comment:

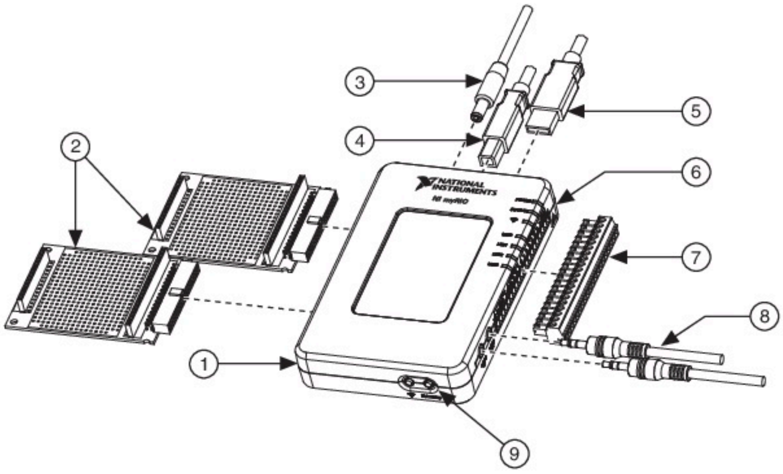
Appendix B

USER GUIDE AND SPECIFICATIONS

NI myRIO-1900

The National Instruments myRIO-1900 is a portable reconfigurable I/O (RIO) device that students can use to design control, robotics, and mechatronics systems. This document contains pinouts, connectivity information, dimensions, mounting instructions, and specifications for the NI myRIO-1900.

Figure 1. NI myRIO-1900



1 NI myRIO-1900
2 myRIO Expansion Port (MXP) Breakouts (One Included in Kit)
3 Power Input Cable
4 USB Device Cable
5 USB Host Cable (Not Included in Kit)
6 LEDs
7 Mini System Port (MSP) Screw-Terminal Connector
8 Audio In/Out Cables (One Included in Kit)
9 Button0

NATIONAL INSTRUMENTS™

Safety Information

⚠ **Caution** Do not operate the hardware in a manner not specified in this document and in the user documentation. Misuse of the hardware can result in a hazard. You can compromise the safety protection if the hardware is damaged in any way. If the hardware is damaged, return it to National Instruments for repair.

Clean the hardware with a soft, nonmetallic brush. Make sure that the hardware is completely dry and free from contaminants before returning it to service.

Electromagnetic Compatibility Guidelines

This product was tested and complies with the regulatory requirements and limits for electromagnetic compatibility (EMC) stated in the product specifications. These requirements and limits provide reasonable protection against harmful interference when the product is operated in the intended operational electromagnetic environment.

This product is intended for use in commercial locations. There is no guarantee that harmful interference will not occur in a particular installation or when the product is connected to a test object. To minimize interference with radio and television reception and prevent unacceptable performance degradation, install and use this product in strict accordance with the instructions in the product documentation.

Furthermore, any modifications to the product not expressly approved by National Instruments could void your authority to operate it under your local regulatory rules.

⚠ **Caution** This product was tested for EMC compliance using myRIO application software. The maximum length for USB cables is 2.0 m (6.6 ft), and the maximum length for signal wires is 30.0 cm (11.8 in.).

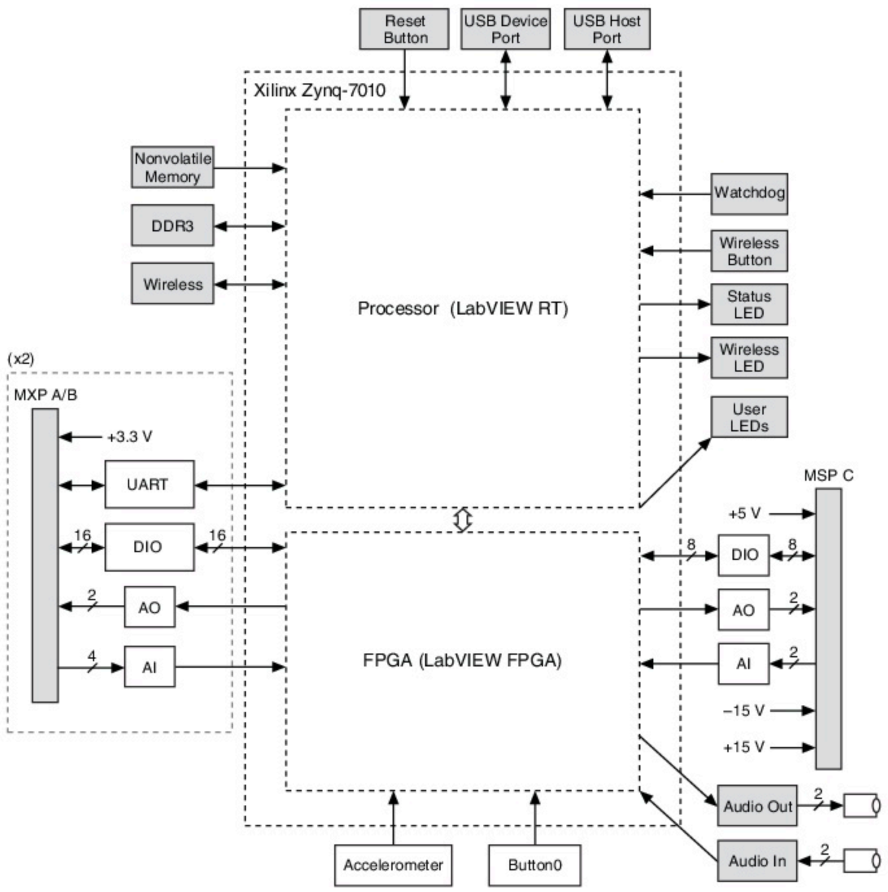
⚠ **Caution** The mounting keyholes on the back of the NI myRIO-1900 are sensitive to electrostatic discharge (ESD). When handling the device, be careful not to touch inside the keyholes.

Hardware Overview

The NI myRIO-1900 provides analog input (AI), analog output (AO), digital input and output (DIO), audio, and power output in a compact embedded device. The NI myRIO-1900 connects to a host computer over USB and wireless 802.11b,g,n.

The following figure shows the arrangement and functions of NI myRIO-1900 components.

Figure 2. NI myRIO-1900 Hardware Block Diagram



Connector Pinouts

NI myRIO-1900 Expansion Port (MXP) connectors A and B carry identical sets of signals. The signals are distinguished in software by the connector name, as in `ConnectorA/DIO1` and `ConnectorB/DIO1`. Refer to the software documentation for information about configuring and using signals. The following figure and table show the signals on MXP connectors A and B. Note that some pins carry secondary functions as well as primary functions.

Figure 3. Primary/Secondary Signals on MXP Connectors A and B

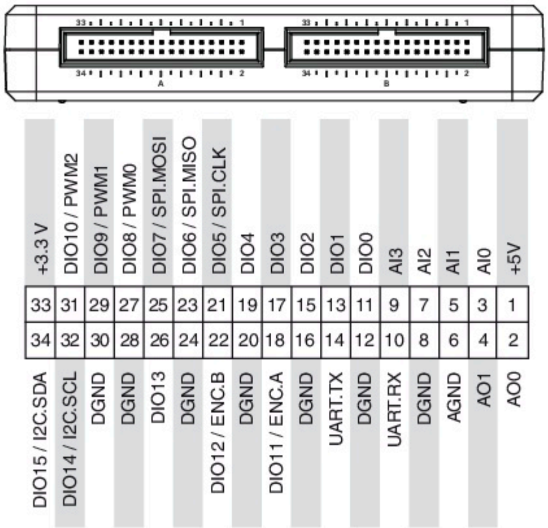


Table 1. Descriptions of Signals on MXP Connectors A and B

Signal Name	Reference	Direction	Description
+5V	DGND	Output	+5 V power output.
AI <0..3>	AGND	Input	0-5 V, referenced, single-ended analog input channels. Refer to the *Analog Input Channels* section for more information.
AO <0..1>	AGND	Output	0-5 V referenced, single-ended analog output. Refer to the *Analog Output Channels* section for more information.
AGND	N/A	N/A	Reference for analog input and output.
+3.3V	DGND	Output	+3.3 V power output.
DIO <0..15>	DGND	Input or Output	General-purpose digital lines with 3.3 V output, 3.3 V/5 V-compatible input. Refer to the *DIO Lines* section for more information.
UART.RX	DGND	Input	UART receive input. UART lines are electrically identical to DIO lines.
UART.TX	DGND	Output	UART transmit output. UART lines are electrically identical to DIO lines.
DGND	N/A	N/A	Reference for digital signals, +5 V, and +3.3 V.

The following figure and table show the signals on Mini System Port (MSP) connector C. Note that some pins carry secondary functions as well as primary functions.

Figure 4. Primary/Secondary Signals on MSP Connector C

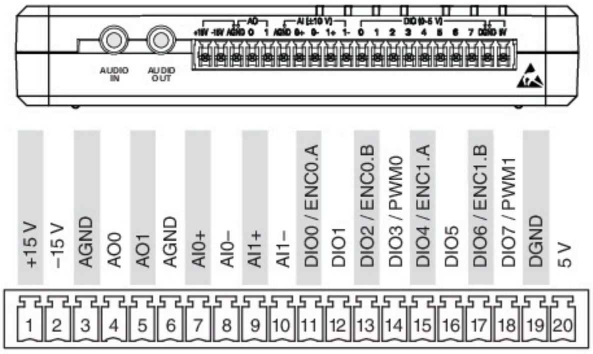


Table 2. Descriptions of Signals on MSP Connector C

Signal Name	Reference	Direction	Description
+15V/-15V	AGND	Output	+15 V/-15 V power output.
AI0+/AI0-; AI1+/AI1-	AGND	Input	±10 V, differential analog input channels. Refer to the *Analog Input Channels* section for more information.
AO <0..1>	AGND	Output	±10 V referenced, single-ended analog output channels. Refer to the *Analog Output Channels* section for more information.
AGND	N/A	N/A	Reference for analog input and output and +15 V/-15 V power output.
+5V	DGND	Output	+5 V power output.
DIO <0..7>	DGND	Input or Output	General-purpose digital lines with 3.3 V output, 3.3 V/5 V-compatible input. Refer to the *DIO Lines* section for more information.
DGND	N/A	N/A	Reference for digital lines and +5 V power output.

Table 3. Descriptions of Signals on Audio Connectors

Signal Name	Reference	Direction	Description
AUDIO IN	N/A	Input	Left and right audio inputs on stereo connector.
AUDIO OUT	N/A	Output	Left and right audio outputs on stereo connector.

Analog Input Channels

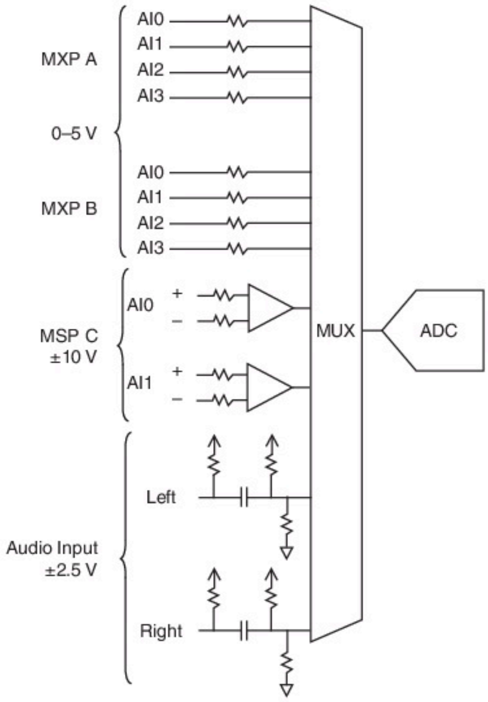
The NI myRIO-1900 has analog input channels on myRIO Expansion Port (MXP) connectors A and B, Mini System Port (MSP) connector C, and a stereo audio input connector. The analog inputs are multiplexed to a single analog-to-digital converter (ADC) that samples all channels.

MXP connectors A and B have four single-ended analog input channels per connector, AI0-AI3, which you can use to measure 0-5 V signals. MSP connector C has two high-impedance, differential analog input channels, AI0 and AI1, which you can use to measure signals up to ±10 V. The audio inputs are left and right stereo line-level inputs with a ±2.5 V full-scale range.

Note For important information about improving measurement accuracy by reducing noise, go to `ni.com/info` and enter the Info Code `analogwiring`.

Figure 5 shows the analog input topology of the NI myRIO-1900.

Figure 5. NI myRIO-1900 Analog Input Circuitry



Analog Output Channels

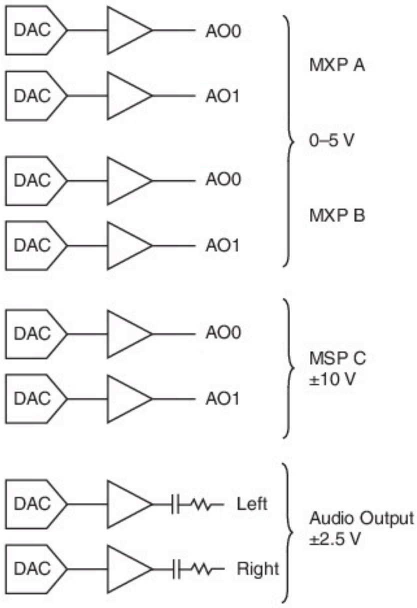
The NI myRIO-1900 has analog output channels on myRIO Expansion Port (MXP) connectors A and B, Mini System Port (MSP) connector C, and a stereo audio output connector. Each analog output channel has a dedicated digital-to-analog converter (DAC), so they can all update simultaneously. The DACs for the analog output channels are controlled by two serial communication buses from the FPGA. MXP connectors A and B share one bus, and MSP connector C and the audio outputs share a second bus. Therefore, the maximum update rate is specified as an aggregate figure in the *Analog Output* section of the *Specifications*.

MXP connectors A and B have two analog output channels per connector, AO0 and AO1, which you can use to generate 0-5 V signals. MSP connector C has two analog output channels, AO0 and AO1, which you can use to generate signals up to ±10 V. The audio outputs are left and right stereo line-level outputs capable of driving headphones.

Caution Before using headphones to listen to the audio output of the NI myRIO-1900, ensure that the audio output is at a safe level. Listening to audio signals at a high volume may result in permanent hearing loss.

Figure 6 shows the analog output topology of the NI myRIO-1900.

Figure 6. NI myRIO-1900 Analog Output Circuitry



Accelerometer

The NI myRIO-1900 contains a three-axis accelerometer. The accelerometer samples each axis continuously and updates a readable register with the result. Refer to the *Accelerometer* section of the *Specifications* for the accelerometer sample rates.

Appendix C

PHILIPS
Lighting

Ledinaire floodlight mini

BVP105 LED25/840 PSU VWB100 MDU

LED Module, system flux 2500 lm - 840 neutral white - Power supply unit - Very wide beam angle 100° - Movement detection unit

The Ledinaire range contains a selection of popular off-the-shelf LED luminaires that comes with the Philips high quality levels at a competitive price. Reliable, energy-efficient and affordable – just what you need.

Product data

General Information	
Number of light sources	-
Lamp family code	LED25S [LED Module, system flux 2500 lm]
Light source color	840 neutral white
Light source replaceable	No
Number of gear units	1 unit
Driver/power unit/transformer	Power supply unit
Driver included	Yes
Optical cover/lens type	Glass flat frosted
Luminaire light beam spread	100°
Embedded control	Movement detection unit
Control interface	-
Connection	Flying leads/wires
Cable	Cable 0.5 m with cable connector 3-pole
Protection class IEC	Safety class I
Flammability mark	-

CE mark	CE mark
ENEC mark	-
Warranty period	3 years
Optic type outdoor	Very wide beam angle 100°
Remarks	*-Per Lighting Europe guidance paper "Evaluating performance of LED based luminaires - January 2018": statistically there is no relevant difference in lumen maintenance between B50 and for example B10. Therefore the median useful life (B50) value also represents the B10 value.
Constant light output	No
Number of products on MCB of 16 A type B	40
RoHS mark	RoHS mark
Light source engine type	LED

Ledinaire floodlight mini

Light Technical	
Upward light output ratio	0
Standard tilt angle posttop	-
Standard tilt angle side entry	-

Operating and Electrical	
Input Voltage	220 to 240 V
Input Frequency	50 to 60 Hz
Inrush current	0.38 A
Inrush time	1 ms
Power Factor (Min)	0.9

Controls and Dimming	
Dimmable	No

Mechanical and Housing	
Housing Material	Polycarbonate
Reflector material	-
Optic material	Glass
Optical cover/lens material	Glass
Fixation material	Stainless steel
Mounting device	Mounting bracket adjustable
Optical cover/lens shape	Flat
Optical cover/lens finish	Frosted
Overall length	164 mm
Overall width	45 mm
Overall height	231 mm
Effective projected area	0.027 m²

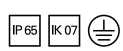
Approval and Application	
Ingress protection code	IP65 [Dust penetration-protected, jet-proof]
Mech. impact protection code	IK07 [2 J reinforced]
Surge Protection (Common/Differential)	2/2 kV

Initial Performance (IEC Compliant)	
Initial luminous flux (system flux)	2500 lm
Luminous flux tolerance	+/-10%
Initial LED luminaire efficacy	90 lm/W
Init. Corr. Color Temperature	4000 K
Init. Color Rendering Index	>80
Initial chromaticity	-
Initial input power	27 W
Power consumption tolerance	+/-10%

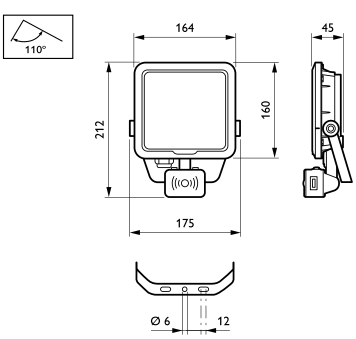
Over Time Performance (IEC Compliant)	
Control gear failure rate at median useful life 35000 h	7.5 %
Lumen maintenance at median useful life* 50000 h	L70

Application Conditions	
Ambient temperature range	-25 to +40 °C
Performance ambient temperature Tq	25 °C
Maximum dim level	Not applicable

Product Data	
Full product code	871869938488399
Order product name	BVP105 LED25/840 PSU VWB100 MDU
EAN/UPC - Product	8718699384883
Order code	912401483142
Numerator - Quantity Per Pack	1
Numerator - Packs per outer box	12
Material Nr. (12NC)	912401483142
Net Weight (Piece)	0.800 kg



Dimensional drawing



Ledinaire floodlight BVP105/106

Appendix D

CorePro LEDtube InstantFit T8

10T8/COR/48-850/IF16/G 25/1

Philips LED T8 InstantFit Lamps are an ideal energy saving choice for existing linear fluorescent fixtures.

Product data

General Information	
Cap-Base	G13 [Medium Bi-Pin Fluorescent]
Main Application	Indoor
Nominal Lifetime (Nom)	50000 h
Switching Cycle	50000X
B50L70	50000 h

Light Technical	
Color Code	850 [CCT of 5000K]
Luminous Flux (Nom)	1600 lm
Luminous Flux (Rated) (Nom)	1600 lm
Correlated Color Temperature (Nom)	5000 K
Color Consistency	<5
Color Rendering Index (Nom)	82
LLMF At End Of Nominal Lifetime (Nom)	70 %

Operating and Electrical	
Input Frequency	25000-105000 Hz
Power (Rated) (Nom)	10 W
Lamp Current (Max)	260 mA
Lamp Current (Min)	100 mA
Starting Time (Nom)	0.5 s
Warm Up Time to 60% Light (Nom)	0.5 s
Power Factor (Nom)	0.9
Voltage (Nom)	120-277, 347 V

Temperature	
T-Ambient (Max)	45 °C
T-Ambient (Min)	-20 °C
T-Storage (Max)	65 °C
T-Storage (Min)	-40 °C
T-Case Maximum (Nom)	50 °C

Controls and Dimming	
Dimmable	No

Mechanical and Housing	
Product Length	1200 mm

Approval and Application	
Energy Saving Product	Yes
Approval Marks	UL certificate RoHS compliance DLC compliance

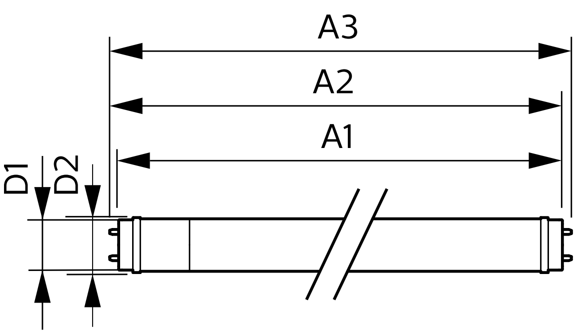
CorePro LEDtube InstantFit T8

DesignLights Consortium Qualified Product List	DesignLights Consortium Qualified Product List

Product Data	
Order product name	10T8/COR/48-850/IF16/G 25/1
EAN/UPC - Product	046677541996
Order code	929001991804

Numerator - Quantity Per Pack	1
Numerator - Packs per outer box	25
Material Nr. (12NC)	929001991804
Net Weight (Piece)	0.215 kg
Model Number	9290019918

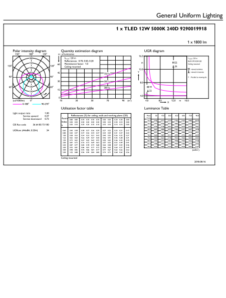
Dimensional drawing



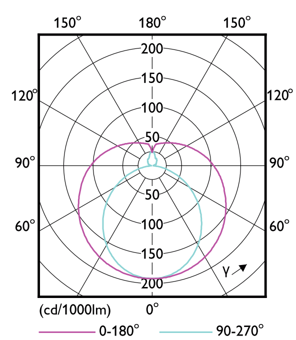
TLED 1200mmT8 120-277 10.5W 1650lm 5000K

Product	D1	D2	A1	A2	A3
10T8/COR/48-850/IF16/G 25/1	25.7 mm	28 mm	1198.1 mm	1205.2 mm	1212.3 mm

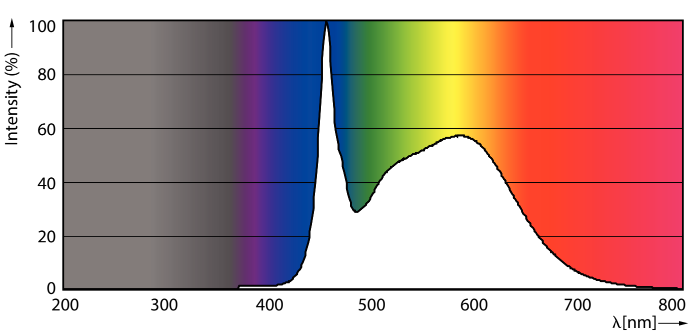
Photometric data



LEDtube 10W G13 850 ND



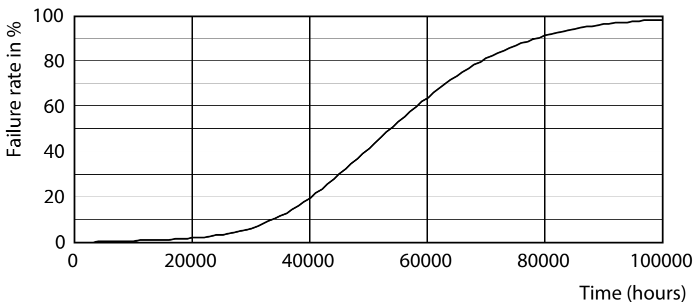
LEDtube 10W G13 850 ND



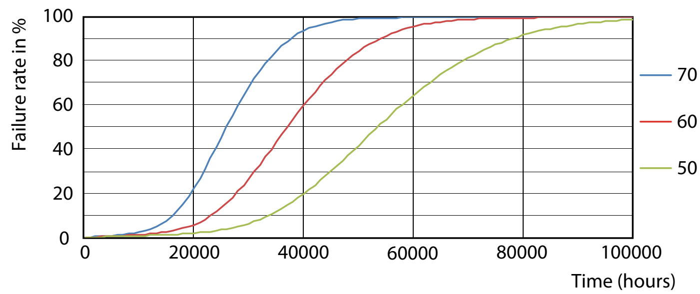
LEDtube 10W G13 850 ND

CorePro LEDtube InstantFit T8

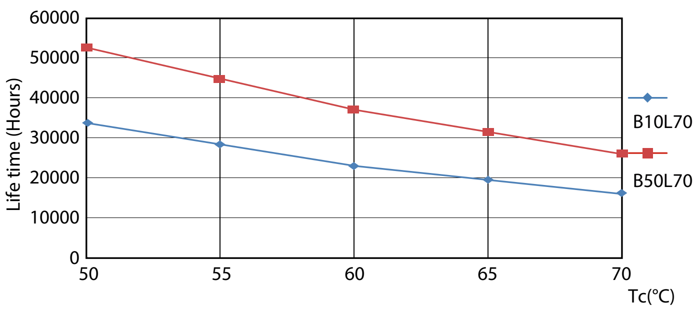
Lifetime



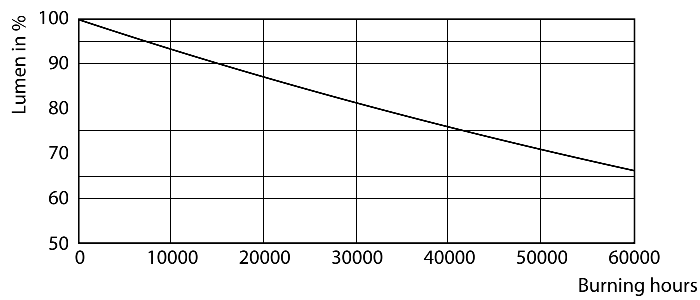
LEDtube 10W G13 850 ND



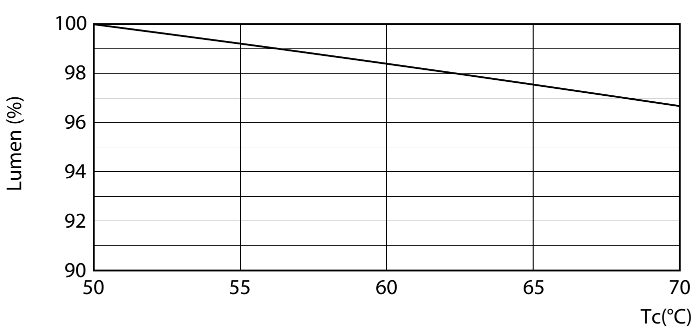
LEDtube 10W G13 850 ND



LEDtube 10W G13 850 ND



LEDtube 10W G13 850 ND



LEDtube 10W G13 850 ND

Appendix E

PHILIPS

Lighting

SceneSwitch LEDbulbs

LEDClassic SSW 60W A60 E27 WW CL ND 1SRT

Some situations call for cool light, others benefit from the ambiance of a warm cozy glow. With Philips SceneSwitch LEDbulbs, you can have different light settings from just one bulb. And you don't need a dimmer! Optimize your lighting for relaxing, hobbies, recreation or working. Simply at the flick of a switch. And that's your existing switch! No extra installation is required.

Product data

General Information	
Cap-Base	E27 [E27]
RoHS mark	RoHS mark
Nominal Lifetime (Nom)	15000 h
Switching Cycle	20000X
Technical Type Setting(s)	7.5-3-1.6-60-30-16 W

Light Technical	
Color Code	827/825/822 [CCT of 2700K/2500K/2200K]
Luminous Flux Setting(s)	806-320-150 lm
Luminous Flux (Rated) Setting(s)	806-320-150 lm
Color Designation	Warm/Extra Warm/Very Warm
Correlated Color Temperature Setting(s)	2700/2500/2200 K
Luminous Efficacy (rated) (Nom)	107.00 lm/W
Color Consistency	<6
Color Rendering Index (Nom)	80
LLMF At End Of Nominal Lifetime (Nom)	70 %

Operating and Electrical	
Input Frequency	50 to 60 Hz
Power (Rated) Setting(s)	7.5-3-1.6 W
Lamp Current (Nom)	70 mA
Starting Time (Nom)	0.5 s
Warm Up Time to 60% Light (Nom)	0.5 s
Power Factor (Nom)	0.51
Voltage (Nom)	220-240 V

Temperature	
T-Case Maximum (Nom)	65 °C

Controls and Dimming	
Dimmable	No

Mechanical and Housing	
Bulb Finish	Clear

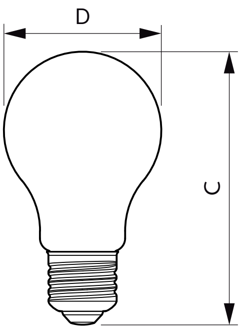
Approval and Application	
Energy Efficiency Label (EEL)	A+
Energy Consumption kWh/1000 h	8 kWh

SceneSwitch LEDbulbs

Product Data	
Full product code	871869674309602
Order product name	LEDClassic SSW 60W A60 E27 WW CL ND 1SRT
EAN/UPC - Product	8718696743096
Order code	929001888601

Numerator - Quantity Per Pack	1
Numerator - Packs per outer box	4
Material Nr. (12NC)	929001888601
Net Weight (Piece)	0.034 kg

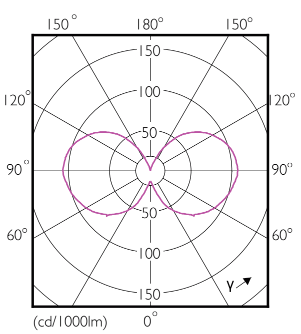
Dimensional drawing



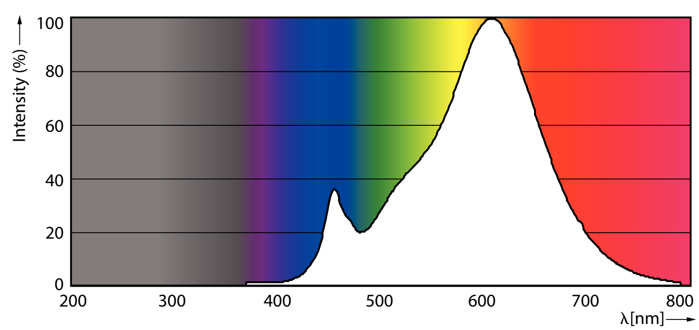
Bulb 806-320-150lm 2700-2500-2200K E27

Product	D	C
LEDClassic SSW 60W A60 E27 WW CL ND 1SRT	60 mm	104 mm

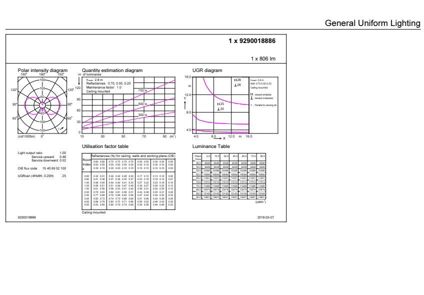
Photometric data



LEDBulb CLA SSW 60W E27 A60 Clear 827-822 ND

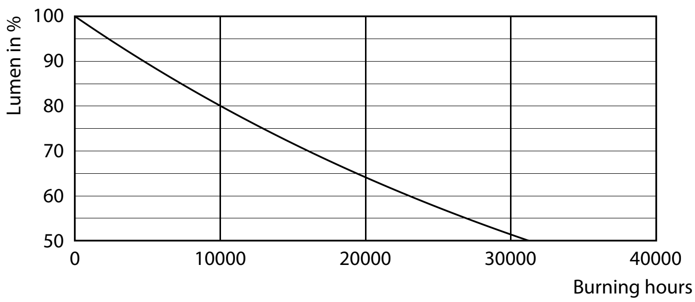


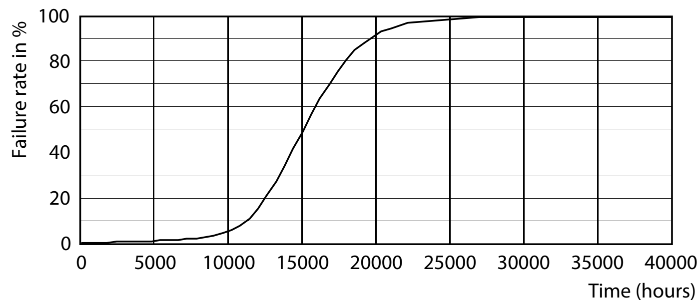
LEDBulb CLA SSW 60W E27 A60 Clear 827-822 ND



LEDBulb CLA SSW 60W E27 A60 Clear 827-822 ND

Lifetime





LEDBulb CLA SSW 60W E27 A60 Clear 827-822 ND

LEDBulb CLA SSW 60W E27 A60 Clear 827-822 ND