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"Design of Fire Alarm and Detection System for Hospital"

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ABSTRACT:-

It is important to choose a building concept that ensures optimal life safety. Time is the most important factor in fire protection such a fire alarm system is design which reduces reaction time, evacuation time, response time and suppression time. Fire safety system is a key element among the fire protection features of any building and specially is a large or high rise building. Because most fire death occurs due to building fire. These paper present techniques to reduce the fire alarm and detection time or in other word a early detection system is design based on PLC and SCADA software. The component are based on smoke detector, heat detector, temperature detector(rate of rise and fixed temp.) severity of fire and location of fire or smoke and alert the nursing station, supervisory station/room and fire control room by using this logic fire is try to control its incipient stage.

Keywords: - Hospital fire, Estimation of fire detection time & Fire detectors, Design based on PLC & SCADA, Automatic fire alarm.

"HOSPITAL FIRE CASE STUDY"

CASE 1
DECEMDER 9, 2011

- In the wee hours of December 9, Kolkata and the nation woke up to see the worst ever hospital disaster of the country. In a devastating fire at centrally-air-conditioned seven-storey annexes building of AMRI- a premier private hospital- 94 people, mostly patients of ICCU, ICU, Intensive Therapy Unit and Critical Care units and orthopedic department were asphyxiated to death.
- Despite claims by the hospital authorities that the fire broke out at 3.30 am and they informed the fire services promptly, the department has refuted the claims and said the fire started at 2.40 am and the hospital took an hour to inform them.

CASE 2:
JANUARY 7, 2012

- BANGALORE: Swift evacuation and timely counter-measures reduced the impact of a fire in the basement of Columbia Asia hospital at Hebbel on Friday afternoon. Within 20 minutes of the accident, hospital officials and firefighters were moved 79 patients out to safer places.
- At 2.45pm, 13 UPS batteries stored in the basement exploded and within 10 minutes, smoke swiftly engulfed the two-storied building. Hospital staff immediately evacuated all the patients, included some on ventilators, those who had undergone surgery a few hours before and women in labour.

"Analysis/Calculation of Fire Accident Last Ten Year"

Year	Month/date	City	Occupancy	Death/Injury
2012	Feb,8	Haridwar	Electronic factory	11 death
2012	July,30	Chennai	Train	32 killed
2011	Dec,9	Kolkata	Amri hospital	89killed
2011	Nov,20	East Delhi	Community function	15 died/30 inj.
2010	March 23	Kolkata	Old mansion	25 killed
2006	April 10		Meerut.	64 killed and 80 injured
2005	September 15	Bihar	Three firecracker	35 dead and 50 injured
2004	July 16	Kumbakonam in Tamil Nadu	School	91 school children were killed
2004	January 23	Srirangam in Tamil Nadu	Marriage hall	49 killed and 40 injured
2001	August 6	Erwadi in Tamil Nadu	At a private mental asylum	: 28 people were killed
1995	December 23	Dabwali (Haryana).	Annual function of a school	442 persons, mostly children, killed
1990	April 16	Patna district	Shuttle train	Seventy killed as

Table no. 1

1. INTRODUCTION

In general the public perceives hospitals as a highly secure facility because its job entitles providing a safe environment for its patients but when a fire threat or hospital patients will have to face while perusing for their health, for example December 9, 2011 AMRI hospital Kolkata and the nation woke up to see the worst ever hospital disaster of the country 89 people where die. This paper chooses the high-rise hospital just like AMRI hospital to design a fire security system for fire occurring within hospital. To design a fire protection system such that it generating a alarm at right place and right timing. The design of a fire alarm system identifying the severity of fire. The system has to sequined the detection and alarm system so as to effectively manage every instated of fire hazards.

"Occupancy Type Classification Codes"

Occ. Type on Permit	Classification
A (1 - 5) B	Assembly Business
E F (1 and 2)	Educational Factory Industrial
H (1 - 5)	Hazardous
I (1 - 4) M R (1 - 4)	Institutional Mercantile Residential
S (1 and 2) U	Storage Utility

❖ **Fire Detection and Alarm Systems**

A key aspect of fire protection is to identify a developing fire emergency in a timely manner, and to alert the building's occupants and fire emergency organizations.
This is the role of fire detection and alarm systems. Depending on the anticipated fire scenario, building and use type, number and type of occupants and criticality of contents and mission, these systems can provide several main functions are as follows_
First, they provide a means to identify a developing fire through either manual or automatic methods.
Second, they alert building occupants to a fire condition and the need to evacuate.
Another common function is the transmission of an alarm notification signal to the fire department or other emergency response organization.
They may also shut down electrical, air handling equipment or special process operations, and they may be used to initiate automatic suppression systems.

❖ **Type of Fire Alarm and Detection Systems**

1) Automatic Detector (Smoke)
2) Automatic Detector (Fixed Temp.)
3) Automatic Detector (Rate-of-Rise)
4) Automatic Detector (Combination)
5) Automatic Detector (Heat)

❖ **Working Principal of Detectors**

- **Heat-sensing fire detectors**

Heat-sensing detectors are designed to respond when the ambient temperature or rate-of-rise of temperature exceeds a predetermined value .Heat-sensing detectors are not effective early-warning devices because they must be very close to a fire to be set off. However, they are useful in places where smoke detectors have a high rate of nuisance alarms, such as a kitchen. They are also useful in areas of the home where smoke detectors cannot function effectively because it is too hot or cold.

❖ **Rate-of-Rise (ROR)**

Heat-sensing detectors react to the sudden change or rise in ambient temperature from a normal baseline condition. Any sudden temperature increase that matches the predetermined alarm criteria will cause an alarm. This type of heat detector can react to a lower threshold condition than would be possible if the threshold were fixed. A typical alarm may sound when the rate of temperature rise exceeds 6.7ºc to 8.3ºc per minute.

❖ **Fixed Temperature**:

Heat detectors react when the ambient temperature reaches a fixed point. The most common fixed temperature point is 58ºC. Recent technological developments have enabled the perfection of detectors that activate at a temperature of 47ºC, providing increased time to escape.

❖ **Smoke-Sensing Fire Detectors:**

Smoke detectors are designed to identify a fire while in its smoldering or early flame stages. The most common smoke detectors are spot type units, such as ionization smoke detector and scattering smoke detector, which are placed along ceilings or high on walls in a manner similar to spot thermal units [4]. They operate on either an ionization or photoelectric principle, This is interpreted as a smoke condition, and the alarm activation signal is transmitted to the fire alarm panel.

❖ **Combination Detectors:**

Combination detector contain more than one element that response to a fire these detector may be designed to responds from on both the rate of rise element will respond quickly to a rapidly developing fire, while the fixed temperature element will respond to slowly developing fire when the detecting element reaches its set point temperature

"Temperature Rating and Application of Fire Detector"

S.NO.	DETECTOR	APPLICATION	TEMP.RATING
1.	Heat sensing fire detector	For Electrical fault detection	Epoxy58ºc.
2.	Smoke sensing detector	Photoelectric smoke detector	-10ºc to50ºc
3.	Fixed temperature	Boiler room	58ºc
4.	Rate of rise	Commercial kitchen ,dish washing area etc	7ºc to8ºc/m
5.	Combination (fixed+ rate of rise)	It is applicable for quick and slow response because it having combination of fixed+ rate of rise	App.7ºc to 50ºc

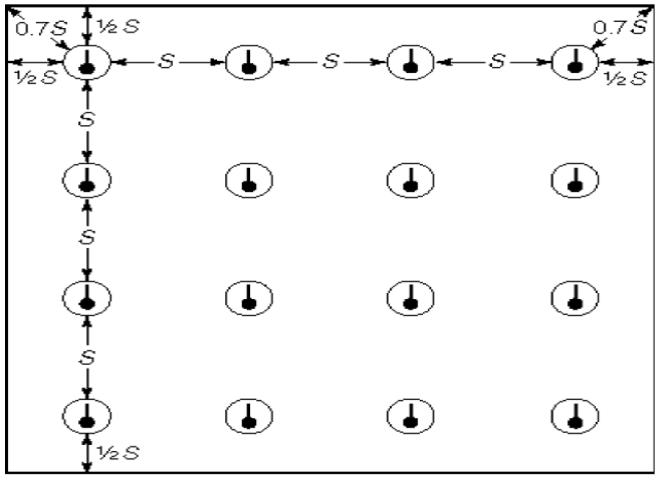
Table no. 2

"Heat Detector Spacing Reduction Based on Ceiling Height"

Ceiling Height Above		Up to and including		Multiply Listed Spacing
m	**ft**	**m**	**ft**	**by**
0	**0**	**3.05**	**10**	**1.00**
3.05	**10**	**3.66**	**12**	**0.19**
3.66	**12**	**4.27**	**14**	**0.84**
4.27	**14**	**4.88**	**16**	**0.77**
4.88	**16**	**5.49**	**18**	**0.71**
5.49	**18**	**6.10**	**20**	**0.64**
6.10	**20**	**6.71**	**22**	**0.58**
6.71	**22**	**7.32**	**24**	**0 .52**
7.32	**24**	**7.93**	**26**	**0.46**

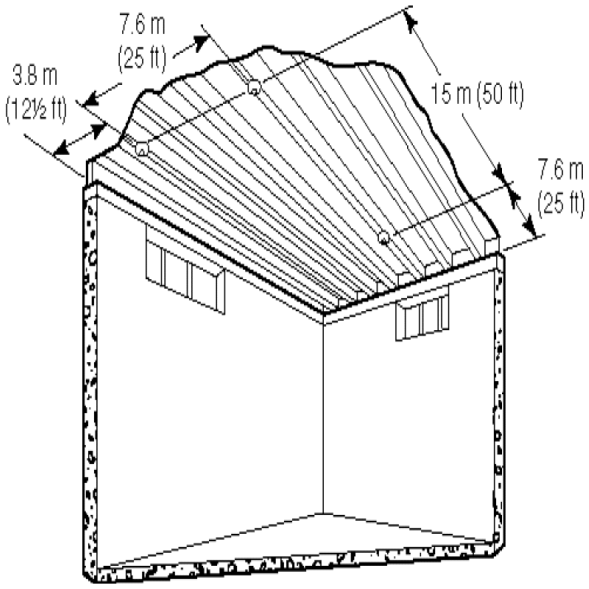
Table no. 3

"Spacing for Spot Type Heat Detector"



= Heat detector
S = Space between detectors

FIGURE A.5.6.5.1(a) Spot-Type Heat Detectors.



RE A.11.8.4 Open Joists, Attics, and Extra-High Ceilings are Some of the Areas that Require Special Knowledge for Installation.

2. ANALYSIS/CALCULATION

❖ **Method for Estimating the Detection Time of Heat Fire Detector.**

$$Q = Q_{conv} = H_c A\left(T_g - T_d\right)$$

Where-

Q total = Total heat transfer to detector; KW
Q conv. = Convective heat transfer, kW
Hc = Convective heat transfer coefficient for detector, kW/(m^2°c)
A = Surface area of the detector's element, $^{m2°c}$
Td = Temperature rating, or set point, of the detector, °c
Tg = Temperature of fire gases at the detector °c

❖ **Fire growth rate**

$$Q = tp$$

Where

Q = Heat release rate, kW
T = Time, s
P = 2

❖ **Heat release rates**

$$Qm = Qa$$

Where

Qm = Max or peak release rate [kw (btu/sec)]
Q = Heat release rate density per unit floor area [kw/m^2(btu/secft^2)]
A= Floor area of the fuel [m^2(ft^2)]

"ACCORDING TO NFPA"

Table B.4.7.4.3 Values of Optical Density at Response (for Flaming Fires Only) [18]

Material	$10^2 D_{ur}$ Ionization	$10^2 D_{ur}$ Scattering	Relative Smoke Color
Wood	0.5	1.5	Light
Cotton	0.05	0.8	Light
Polyurethane	5.0	5.0	Dark
PVC	10.0	10.0	Dark
Variation	200:1	12.5:1	

Table B.4.7.5.3 Temperature Rise for Detector Response [18]

Material	Ionization Temperature Rise °C	Ionization Temperature Rise °F	Scattering Temperature Rise °C	Scattering Temperature Rise °F
Wood	13.9	25	41.7	75
Cotton	1.7	3	27.8	50
Polyurethane	7.2	13	7.2	13
PVC	7.2	13	7.2	13
Average	7.8	14	21.1	38

3. SYSTEM RESPONSE

- Detection (detector delays, control panel delays and so forth).
- Notification to the monitoring station (remote nursing station, central station, proprietary, and so forth).
- Notification of the fire control room of hospital.
- Alarm handling time at the fire department.
- Turnout time at the station.
- Travel time to the incident.
- Access to the site.
- Set-up time on site.
- Access to building.
- Access to fire floor.
- Access to area of involvement.
- Application of extinguisher on the fire.

4. SUPERVISORY RESPONSE

The two telephone lines (numbers) one at the supervisory central station connected to the public fire control room. The term immediately "without unreasonable delay." Routine handling should stake a maximum of 90 seconds to inform public fire control room as well as retransmit the fire message to local fire control room when a fire alarm messages come on its station without leaving its place. It is anticipated that the central station will first attempt to notify designated Personnel at the protected premises.

The term immediately in this context is intended to mean "without unreasonable delay." Routine handling should take a maximum of 4 minutes from receipt of a supervisory signal by the central station until the initiation of communications between the nearest nursing stations manually identifies the fire spot.

The term immediately in this context is intended to mean "without unreasonable delay." Routine handling should take a maximum of 4 minutes from receipt of a trouble signal by the central station until initiation of the investigation by telephone.

Building functions that should be initiated or controlled during a fire alarm condition include, but should not be limited to, the following:

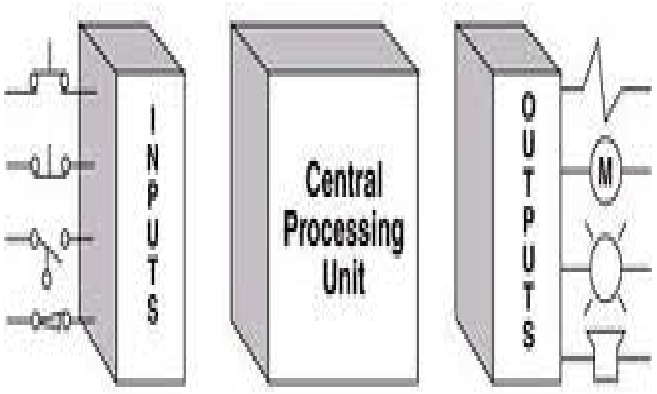
- Unlocking of stairwell and exit doors
- Release of fire and smoke dampers
- Monitoring and initiating of self-contained automatic fire extinguishing system(s) or suppression system(s) and equipment
- Lighting control necessary to provide essential illumination during fire alarm conditions.
- Emergency shutoff of hazardous gas
- Control of building environmental heating, ventilating, and air-conditioning equipment to provide smoke control
- Control of process, data processing, and similar equipment as necessary during fire alarm conditions

5. PROCESS MONITORING METHOD

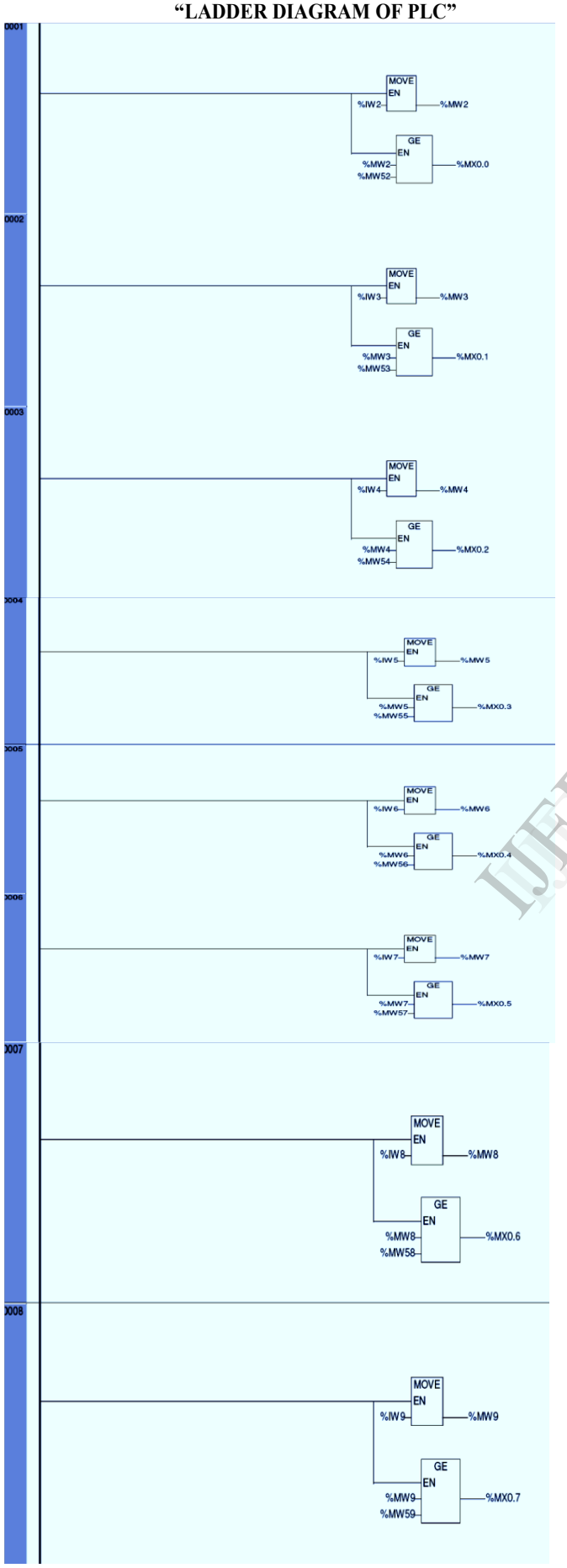
5.1 Plc (Programmable Logic Controller)

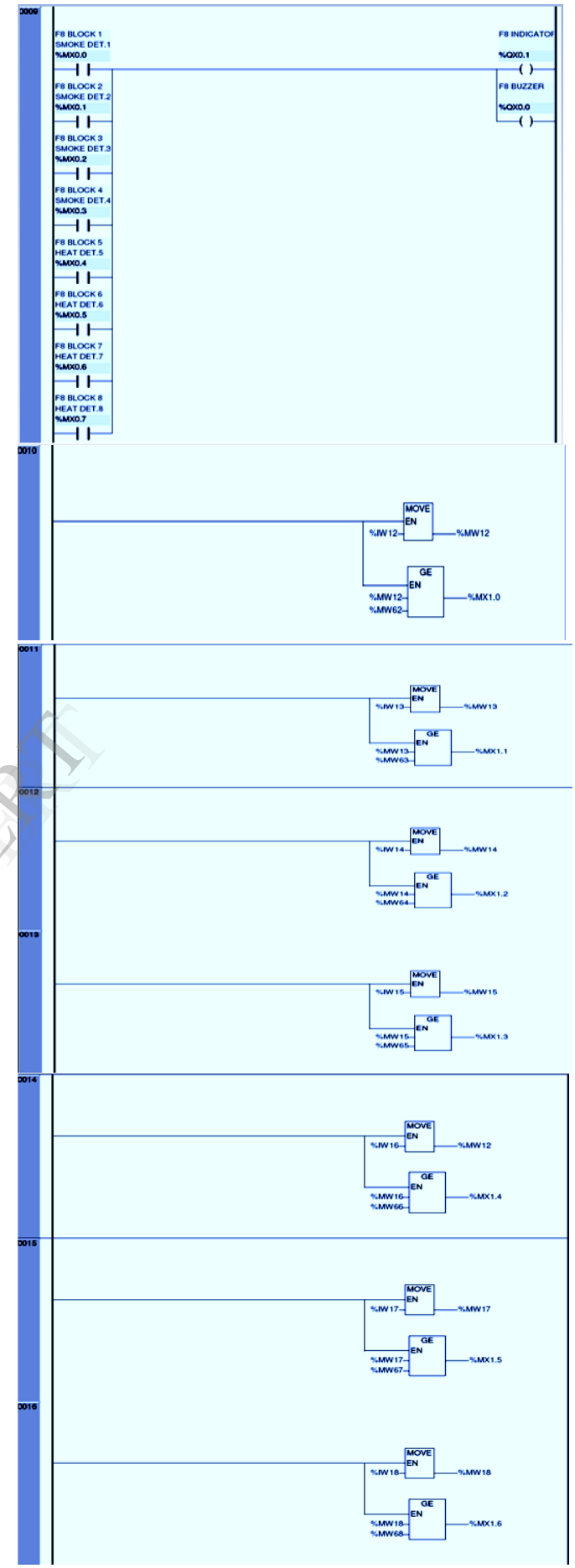
A programmable logic controller (PLC) or programmable controller is a digital computer used for automation of industrial processes, such as control of machinery on factory assembly lines. Unlike general-purpose computers, the PLC is designed for multiple inputs and output arrangements, extended temperature ranges, immunity to electrical noise, and resistance to vibration and impact. Programs to control machine operation are typically stored in battery-backed or non-volatile memory. A PLC is an example of a real time system since output results must be produced in response to input conditions within a bounded time, otherwise unintended operation will result.

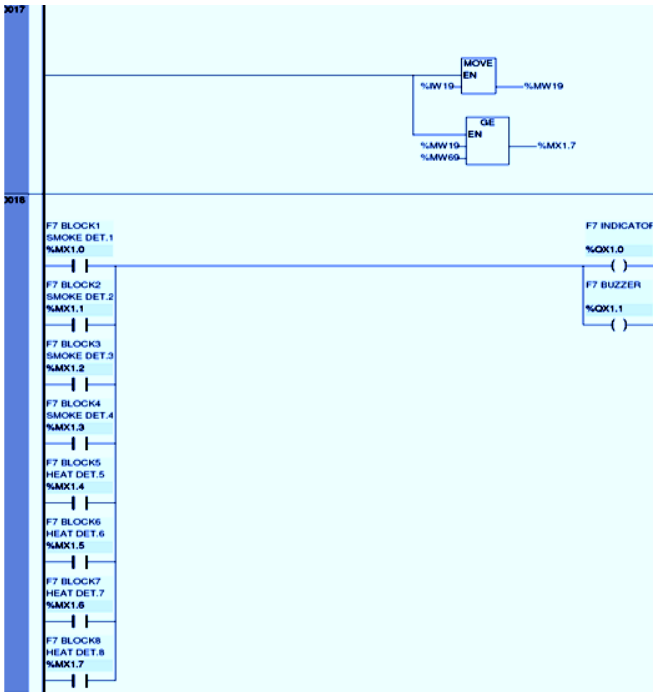
Hence, a programmable logic controller is a specialized computer used to control machines and processes. It therefore shares common terms with typical PCs like central processing unit, memory, software and communications. Unlike a personal computer though the PLC is designed to survive in a rugged industrial atmosphere and to be very flexible in how it interfaces with inputs and outputs to the real world.



"LADDER DIAGRAM OF PLC"



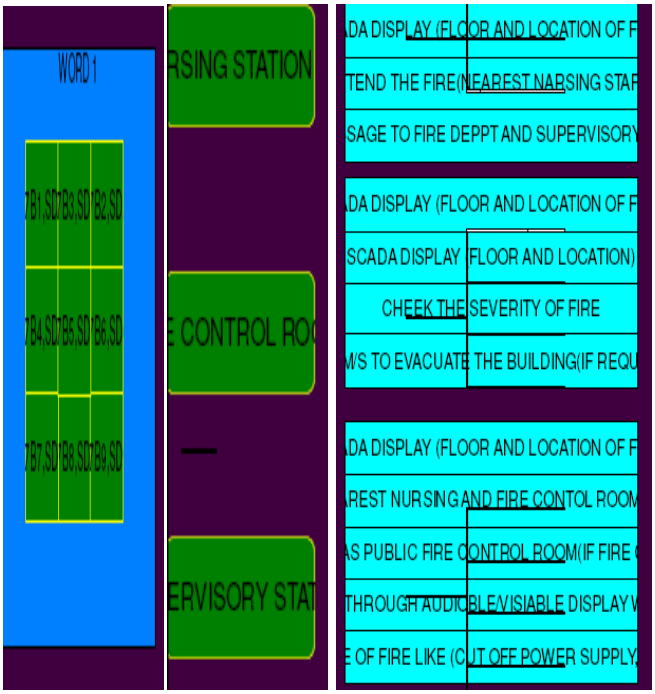




5.2 Addressing for Plc (Programmable Logic Controller

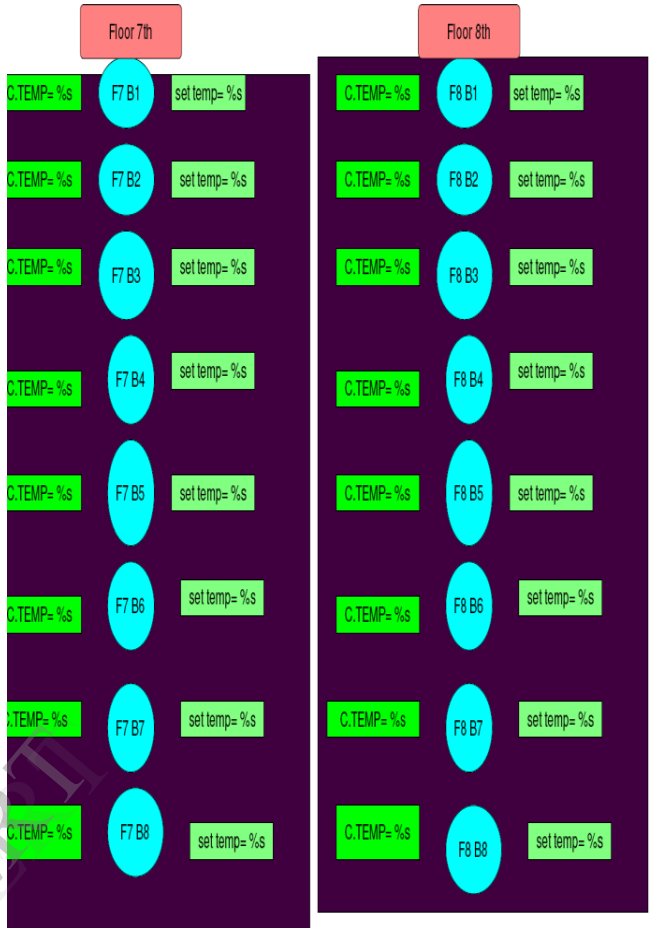
FLOOR/BLOCK	INPUT/ALARM	OUTPUT/INDICATOR/BUZZER
F7,B1toF7,B7	%MX1.0 to%MX1.7	%QX1.0 to%QX1.1
F8,B1toF8,B7	%MX0.0 to%MX0.7	%QX0.0 to%QX0.1

5.3 Scada Visualization of System Response at Time of Fire in a Hospital



5.4 Scada Visualization of Hospital Floor

"Basic Scenario of Hospital Floor"



5.5 Fire Scenario of Hospital Floor

"Fire Scenario of Hospital"

Floor7/Input	Basic scenario	Fire scenario
c.temp/f7 b1/set temp to c.temp/f7b8/set temp	At normal condition when no fire than alarm having blue color	At condition when fire than alarm indicating red color

Table no. 4

6. CONCLUSION

This paper discusses design of fire alarm and detection system for a hospital with the help of software PLC (programmable logic controller) and SCADA (supervisory control and data acquisitions). It result if ignition start inside the hospital on any of the floor it will detect the fire at its incipient stage with the help of smoke and heat Detector and system will response according to the PLC addressing System through this if any wrong is happened in a hospital building Message is convey to nearest nursing station, fire control room, supervisory control room through SCADA visualization .PLC will take only a few second to inform to whole system with help of this We can reduce the reaction time ,early warning system ,suppression time, and all this process is done by automatic detector system synchronized by programmable logic controller .In future we can also design it wireless system so its complexity will reduce .so with the help of this we can say the fire accident just like AMRI, hospital or other building fire is try to control so we can save life as well as the property loss.

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