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Programmable Logic Control (PLC)-Based Fire Alarm System

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Abstract*: *The main goal of the study was to assemble a PLC-Based Fire Alarm System and to find its performance in the aspect of smoke and heat detection and its effect to the automatic alarm and automatic sprinkling by using a Programmable Logic Controller (PLC). The study was conducted at Bohol Island State University-Main Campus, Tagbilaran City, Bohol in the Academic Year 2016 – 2017. The study utilized the experimental design of research. The researcher has chosen twenty (20) electrical and electronics instructors to validate the performance of the device and ten (10) experts from other learning institutions and private industries in the Province of Bohol to assess the acceptability of the device. Upon the assembly, various trial-and-errors conducted until the device was 100% functional. The performance of the device was rated through an observation guide. A self-made questionnaire was given to the respondents to find the acceptability level of the PLC-Based Fire Alarm System. The researcher gathered all the data, analyzed and interpreted the result. Based on the results of the study, the level of performance of the device got a general rating of 3.54 which described as "Very Good" and was found out to be highly acceptable to the respondents. This means that using PLC as the main controller in a fire alarm system was highly acceptable. The PLC-Based Fire Alarm system will be used to provide notification in case a fire emergency will occur in a building.

Index Terms*: *acceptability level, device, performance level, technology

I. INTRODUCTION

More and more things are becoming automated nowadays. Automation is a step beyond mechanization, where humans are provided with machines to help them with their jobs, or simply replace them. Automation is a wide variety of systems in which there is a significant substitution of mechanical, electrical, or computerized action for human effort or intelligence [1][9]. The technology exists from simple to complex ones. Automation process needs a logic controller to perform the sequenced task. A programmable logic controller **(**PLC) is an electronic device used in many industries to monitor and control building systems and production processes. PLC is designed to perform a single set of tasks, except under real-time constraints and with superior reliability and performance [2][10][11]. To meet the demands of harsh industrial environments, PLCs are designed to be extremely robust, often capable of withstanding extreme temperatures, humidity, vibration, and electrical noise [3].

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The input/output system forms the interface by which fields devices are connected to the controller. The main purpose of interfaces is to condition the various signals received from or sent to external field devices. Incoming signals from the sensor are wired to terminals on the input interfaces. Devices that will be controlled, like the motor starter, solenoid valves, pilot lights, and position valves, are connected to the terminals of the output interfaces. The system power supply provides all the voltages required for the proper operation of the various central processing unit sections [4][13][14][15].

Fire alarm systems provide notification of fire emergencies in an area or an entire building. Fire detectors are designed to detect fire, smoke, heat, and flame [5]. Fire detection and alarm system is a key element for people to survive. 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 [6]. Survival depends on time from recognition to evacuation.

PLC can perform the same function as fire alarm control. PLC is a programmable device which the user can change only the program instead of rewiring the whole system. It needs only less effort to change the program than to change the whole wiring system. When using PLC, the operator can put an address indicating the function of the different device for what is it intended. The PLC-Base Fire Alarm system will automatically detect smoke, and fire that pass by various sensing devices. A sensor employs one or more transducers to detect and measures phenomena such as temperature, humidity, barometric, pressure, texture, proximity and the presence of certain substances [7].

Sensor reacts to change in physical conditions by altering their electrical properties. Thus, most artificial sensor relies on the electronic system to capture, analyze and relay information about the environment [15]. This electronic system relies on the same principle as electrical circuits work. The sensor device is used by human to improve the technology and becomes more useful to everyone which is less effort but more function that being done [5]. Moreover, the main objective of the researcher was to assess the performance and the acceptability level of the Fire Alarm System using Programmable Logic Controller.

II. METHODS

A. Design

This study utilized the experimental design in the assembly of PLC-Based Fire Alarm System. Upon the assembly of the device, various trial-and-errors conducted until the device was 100% functional.

The performance of the device has done through observation guide. A questionnaire was given after the experiment for the acceptability level of the
PLC-Based Fire Alarm System in order to gather the necessary data. After the participants answered the self-made questionnaire, the researcher gathered all the data, analyzed and interpreted the result.

B. Environment and Participants

The study was conducted at Bohol Island State University Main Campus (BISU-MC), Tagbilaran City, Bohol. BISU is a technical school that offers courses such as Engineering and Industrial Technology courses. The assembly of this device was done in the electrical shop because the facilities, tools and equipment's required during the assembly of the project were available.

The respondents of the study were twenty (20) electrical and electronics instructors to validate the performance of the device and ten (10) experts from other learning institutions and private industries in the Province of Bohol to assess the acceptability of the PLC-Based Fire Alarm System.

C. Instruments

The researcher formulated a self-made questionnaire for gathering the data from the selected respondents. The questionnaires serve as the basis for determining the performance of the device. The questionnaire was submitted to the adviser for correction and suggestion. After that pilot testing was conducted, an observation guide was provided reflecting their description on the performance of the device. The collective data was computed and analyzed. A questionnaire was also distributed to the respondents to assess the acceptability level of the device.

III. RESULT

Table I
Performance Level of the PLC-Based Fire Alarm System in Terms of Detection;

Sample materials	Trial	Distance (Ft.)	Smoke Detector		Heat Detector	
			Time	Response	Time	Response
Woods	1	0.5	10 sec.	Contact Closed	5 sec.	Contact Closed
	2	1	15 sec.	Contact Closed	25 sec.	Contact Closed
	3	1.5	18 sec.	Contact Closed	40 sec.	Contact Closed
Paper	1	0.5	8 sec.	Contact Closed	6 sec.	Contact Closed
	2	2	10 sec.	Contact Closed	15 sec.	Contact Closed
	3	3	24 sec.	Contact Closed	13 sec.	Contact Closed
Plastic	1	0.5	8 sec.	Contact Closed	20 sec.	Contact Closed
	2	1.5	47 sec.	Contact Closed	43 sec.	Contact Closed
	3	2	33 sec.	Contact Closed	72 sec.	Contact Closed

The researcher found out that the distance observed during the detection process was shorter because the size of the device affects the distance of the detection. The data gathered in the detection process signify that the distance was greatly affected by the structure because when the detector is located at the area in which it is near to the sample materials, it only takes a shorter time to be detected. When the location of the detector is too far from the detector it will take a longer time to be detected. It is very important to install this detector to the appropriate place in order to function well and to avoid unwanted alarm.

Table II
Performance Level of the PLC-Based Fire Alarm System in Terms of Alarm Response and Sprinkling Syatem;

Sample materials	Trial	Response of automatic alarm		Response of automatic sprinkler		Description
		Time	Distance that the alarm could be heard	Time	Volume of water	
Woods	1	5 sec.	20m	5 sec.	2 liters	Functional
	2	5 sec.	20m	5 sec.	2 liters	Functional
	3	5 sec.	20m	5 sec.	2 liters	Functional
Paper	1	5 sec.	20m	5 sec.	2 liters	Functional
	2	5 sec.	20m	5 sec.	2 liters	Functional
	3	5 sec.	20m	5 sec.	2 liters	Functional
Plastic	1	5 sec.	20m	5 sec.	2 liters	Functional
	2	5 sec.	20m	5 sec.	2 liters	Functional
	3	5 sec.	20m	5 sec.	2 liters	Functional

It was observed by the researcher that the distance of the automatic alarm was heard in a constant distance because the loudness and range area of the alarming system defends on the sounder, if the sounder is big then the range that can be heard is longer than the smaller one.

It was also observed that the volume of water pumped by the motor depend on the time used in making the program. Since it was programmable the amount of water that can be produced by the water pump was changeable and can be manipulated by the assigned person. To produce a large amount of water, just set the program in the longest time possible. During the pilot testing, the researcher tried to measure the amount of water that the motor pump can be produced during the operation.

Table III
Acceptability Level of the PLC-Based Fire Alarm System

Acceptability level	Experimental		
	WM	Description	Rank
3.1 Performance			
3.1.1 As a device			
The smoke detector will detect smoke at the given distance.	3.62	Very Good	
The heat detector will detect heat with the given distances.	3.68	Very Good	
The response of automatic alarm either in smoke or heat is detected.	3.93	Very Good	
The response of automatic sprinkler either smoke or heat is detected.	3.81	Very Good	
Average:	3.76	Very Good	1st
3.2 Convenience			
The parts and terminals are properly labeled for identification.	3.00	Good	
Leads are provided with for easy installation.	3.68	Very Good	
All the parts and terminal are visible	3.75	Very Good	
Exposed terminals are provided for easy installation.	3.87	Very Good	
Table for the tools is provided.	3.68	Very Good	
Locker is provided for the materials to be stored.	3.87	Very Good	
Average:	3.64	Very Good	3rd
3.3 Safeness			
Circuit breaker and other safety devices are provided for the safety of the operator.	4.00	Very Good	
The parts and accessories are properly installed.	3.44	Very Good	
The device is well grounded.	3.75	Very Good	
Average:	3.73		2nd
3.4 Cost			
The total cost of the device is Php. 20,000.00	3.06	Good	4th
Average weighted mean	**3.54**	**Very Good**	

The acceptability level of PLC-Based Fire Alarm System in terms of the performance with 3.76 weighted mean which is rated as Very Good, safeness with a 3.73 weighted mean that described as Very Good, the convenience which was described as Very Good with a 3.64 weighted mean, and cost of the device with 3.06 was generally describes as "Good" with the General Weighted Mean of 3.54. The highest rating of acceptance factor is in terms of performance with an average weighted mean of 3.76 and described as "Very Good.

IV. FINDINGS

After the data were gathered and translated, the researcher was able to answer the following results: The performance level of the PLC-Based Fire Alarm System in terms of detection, the response of automatic alarm, and response of automatic sprinkle were observed. First, the smoke and heat detector was able to detect the presence of heat and smoke. Secondly, the response of the automatic alarm when heat and smoke have been detected was observed. Lastly, the response of automatic sprinkler when heat and smoke have been detected was observed. The acceptability level of PLC-Based Fire Alarm System in terms of the performance with 3.76 weighted mean which is rated as Very Good, safeness with a 3.73 weighted mean that described as Very Good, and the convenience which was described as Very Good with a 3.64 weighted mean with the General Weighted Mean of 3.71. The highest rating of acceptance factor is in terms of performance with an average weighted mean of 3.76 and described as "Very Good.

V. CONCLUSION

The PLC-Based Fire Alarm System performed efficiently based on the result of all the observations and also resulted in high performance in functionality. The acceptability level of the device described as very good because the experts relate the usefulness of the device especially in saving the life of the people in a certain building in case of a fire emergency. Thus, using PLC-Based Fire Alarm System to provide notification in case of fire emergency was highly acceptable.

VI. RECOMMENDATION

a. The researcher may introduce the device to the home and establishment owner to use this device as their new ways of protecting and suppressing fire because of its convenience of use and for the easy operation.
b. The researcher may introduce the device to the BS Electrical student in Bohol Island State University-Main Campus in order for them to realize the essential importance of using PLC on different applications.
c. For the Instructors, the device can be served as an additional instructional device used in teaching the students in programming, installing and operating a PLC-Based Fire Alarm System
d. For the future researchers, innovations, and upgrades of the device shall be developed. A related study may be conducted for more sophisticated designs for the device.

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