Real-Time Industrial Environment Monitoring System Design

Hamed M. Almalki

Abstract: This work is focused on, utilizing the interdisciplinary advances in different engineering fields, to suggest a new design form with modified capabilities of an efficient, real time, reliable and realizable, at low cost, industrial environment monitoring system. The suggested design is intended to monitor, track, assess and register pollution's sources parameters and conditions in industrial manufacturing factory, to result in ensuring acceptable quality of factory's environment, maintain safety of personnel, Material and Machinery and finally to result in more optimized factory operation. The system design is developed by utilizing commonly available hardware and specially designed modules. The state and value of various environmental pollution sources and conditions, in real time, are continuously read and monitored. The acquired data are broadcasted wirelessly from all sensor modules, to main control unit, which will process the acquired data, calculate the climatic indices, and take correction actions.

Index Terms: Environment monitoring, Smart system, Wireless communication, Design.

1 INTRODUCTION

Nowadays, industries are affecting the modern world in different aspects including luxury, security, safety and economy, by enabling mass production of various types of goods to cater the increasing needs and requirements of ever-increasing population. Beside industry's positive effects, industries have negative impacts; one of it is the industrial harmful pollution outputs that affect both the world climate and the local production environments. It is of need to suggest a suitable design for distant monitoring and registration of industrial environment system parameters that will result in good manufacturing practice and more optimized factory operation. This work is focused on utilizing the interdisciplinary advances in different engineering fields, to suggest a new theoretical design form with modified capabilities of a reliable and realizable at low cost, of an industrial environment monitoringsystem. The main purpose of the suggested design in this research work is to monitor, track and register pollution's sources parameters in industrial manufacturing factory, to result in ensuring acceptable quality of factory's environment, maintain safety of personnel, material and machinery and finally to result in more optimized factory operation. Industrial Environment monitoring is the process of defining the current industrial factory environment state and conditions, by collecting data at various and specific factory's locations, at different time intervals, compare the acquired data with desired reference levels and take best correction actions. Factory environmental monitoring can include each of the following; monitoring optimal quality of all and each of Air, water, Light, Temperature, Humidity, Noise, combustible Gases and many others.

1.1 Industrial Pollution: types, causes and effects

Industrial Pollution can be classified into the following types; Water, Air, Light, Noise, Soil. Thermal and Radioactive Pollutions. There exist extensive activities causing pollution in industrial manufacturing factory. The most top causes and sources of industrial pollution can be summarized as following: a) Burning fuels e.g. oil, natural gas, coal and petroleum. b) Using Chemical solvents. c) Untreated gas and liquid waste. c) Water Pollution, in a running manufacturing process, the water is exposed to different pollution sources, including chemicals, heavy metals, and organic sludge. d) Air pollution, is caused by smoke, gases and dust released by various industries. e) Loud noises caused by Industrial processes Effects of Industrial Pollution on human health can include: a) It increases both mortality rate and morbidity rate by causing chronic pulmonary diseases (e. g. The air pollution has an impact on everyone, every day it is the reason for many illnesses, increasingly frequent over time including bronchitis and asthma), hearing difficulties, b) irritation of eye, nose, throat respiratory tracts, etc. c) Poisoning.

1.2 Related works

A number of research works and projects have been conducted as industrial environment monitoring system to measure different types of pollutants and sources Industrial Environment, monitor, track and control this process. For exampleAuthors in [1] introduce an online pollution monitoring system for controlling pollution caused by untreated disposal of waste. MYSQL was used to online update database with pollution parameters values. For monitoring and controlling, a website is designed and hosted. An android application was developed, to increase designed system reliability and flexibility. In [2] for real time monitoring of various environmental conditions, authors described the design of an operative prototype based on Internet of Things (IoT) concepts with the help of several sensors, the various environmental conditions e.g. temperature and air pollution are continuously monitored, processed and controlled by Microcontroller. The collected data are broadcasted through internet with an ESP8266 Wi-Fi module. An industrial air pollution monitoring system design, for manufacturing industries, based on wireless sensor network was introduced in [3]. The system is designed such that it enables sensor readings to be send, within time constraints, so that appropriate actions taken, and allows regulatory agency to take necessary action whenever pollution occurs. The analysis focuses on six substances, ozone, particulate matter, sulphur oxides, nitrogen oxides,

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carbon monoxide, and lead. In [4] to minimize the problem of cost and regular pollution inspections, authors suggested a design of an industrial pollution monitoring system using Labview and GSM. The system was designed achieve both of controlling the sources causing pollution and to minimize the effect of resulted pollution parameters without affecting the plant or natural environment. In industry effluents, the designed system examines the level of pH, level of CO gas and temperature of the machineries. For communication, the signals were transferred to control and authorities using GSM. The suggested design was implemented using LabVIEW software. In [5] in order to provide a healthy environment for the workers, authors attempt to build a robust system to measure industrial pollution and help to decrease human interference in monitoring the industrial pollution. The system is designed to continuously assess the pollution in an industrial location and indicate if there is an increase in the emissions levels, make decision and take proper correction action to control it, using wireless Internet of Things technology. In [6] an IoT based low cost environment monitoring system was present. The design, implementation and testing was introduced and discussed. In the design it was proofed that IoT based platform is reliable for environment parameter monitoring. The designed system transmits the read by sensors data to an API called ThingSpeak utilizing an HTTP protocol and allows storing of data. In [7] Design of Environment Monitoring and Control System is presented, the system was designed utilizing wireless sensor Networks for reading the sourrounding environment for the next parameters; the pressure temperature, and humidity. The Control part of the system was developed based on ARM11 raspberry pi board, and designed to start the control adjusting action, when any of parameters is out of desired range. This work is organized as follows. Section 2, provides system design methodology. In section 3, System configuration, hardware design and integration. In section 4, suggestions regarding subsystems and overall system Prototyping. Finally conclusions and future work.

2. SYSTEM DESIGN, METHODOLOGY AND HARDWARE

2. 1 System Methodology and working principle

Secondary Industries are divided into two types, a) Process industries, e.g. chemicals, pharmaceuticals, petroleum, and food. b) The manufacturing industries, e.g. aircraft, appliances, machinery, and parts that these products are assembled from. The suggested environment monitoring system design solution, presented in this work, is intended to be applied in manufacturing industries workshop floor, in our case, the factory designed for metal processing operations in terms of turning, forming, welding and similar processing operations. But the suggested industrial monitoring concept can be expanded to be applied to any industrial zone. The methodology, as depicted in Figure 1, by utilizing different groups of transmitter/sensors, the industrial monitoring system is to be designed to acquire maximum possible data about factory industrial environment and pollution's levels, values, sources state and conditions, input these readings to local control unit, that will process acquired data readings and transmit it wirelessly, to main control unit, that is programmed with algorithm, to perform data analysis. based on both, readings from transmitters and reference set points, take smart correction decisions, these decisions are send, wirelessly, to final control element/actuators, to adjust the factory environment to meet desired levels, also display readings on LCDs and notify supervisor and personnel in case of environmental state meets critical conditions. A suitable choice for control unit is Microcontroller, with advantages like significantly reducing the cost, ease of wiring and simplicity of establishing direct wireless communication e.g. radio or internet. The communications and interfacing: Due to the factory large space, and the need to distribute transmitters over an area of interest (e.g. near pollution sources and remote locations) in factory, the need of acquiring an accurate readings and control of pollution status and levels and to allow specific actions for the protection and solving, finally for ease of components interfacing and communication, in the suggested design, short range wireless communication are utilized. In suggested setup, the transmitters, final control elements and control unit are interfaced either wirelessly using radio transceivers or by wifi communications. Real time methodology is to be applied, the monitoring system is operating in real time, continuously takes readings and monitors states and conditions, sends signals to control unit, which in real time, take smart adjusting and notifying decisions, including; notify supervisor and displays results. To achieve economy in terms of in factory 'power consumption, related to lighting, the system is designed to maintain the desired set-point level of illumination inside factory workshop. Two states of illumination are to be considered: a) the level of sun light illumination inside factory floor is less than desired reference illumination range, then, compensate the shortage, by switching a number of lights ON , step by step, until the illumination level falls within the desired range. b) The level is greater than desired reference illumination range. Then, achieve desired range, by switching a number of lights OFF, step by step, until the illumination level falls within the desired.
Hardware integration/placement: to read the pollution sources and levels in factory environment, data need to be collected from various locations, transmitter are to be placed in the most suitable locations to detect, monitor and take readings, examples on transmitters placement include: a) near sources of pollution (e.g. gases, fuels combustion, noise), b) in other location to read the impact of pollution source on overall factory environment (e.g. factory ceiling to read gases or illumination levels).

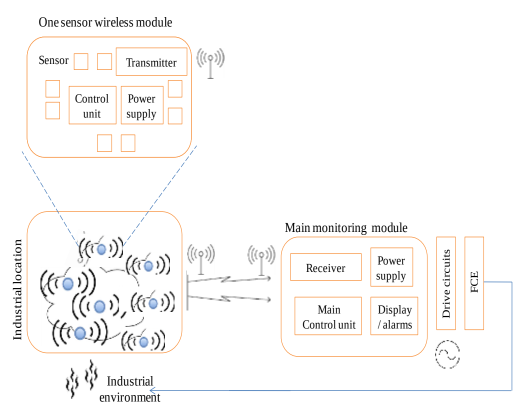

***Fig. 1**: The methodology applied and system design*

2.2 The permissible amount of harmful industries outputs

and measuring units

The permissible amount of harmful industries outputs for world and working ambient environment, have been quantified, regulations are set. These are to be applied when implementing and testing the physical prototype, the read values are to be compared to these permissible amounts. Two examples on the permissible amount of harmful industries outputs, could be, a) The carbon monoxide gas (CO), is estimated in units 'Parts Per Million (ppm)' and percent (%). a conversion example from ppm to percentage is shown in Table-1. Carbon Monoxide source and the its concentrations is shown in Table-2.[8]. , b) the pH level; the applied ph scale is developed with ranges [0 – 14]. In general, water is considered acidic and corrosive, if it is with a pH less than seven [PH < 7]. On the other hand water is considered basic with a pH > 7. For specific cases, the acceptable range can be considered as (Max value of 7.5 and Min value of 6.5). When the detected pH value is out of the acceptable range, that less than 6.5 or greater than 7.5, this pollution level is reported to supervisor, ventilation system is switched ON, this pH value is sent to displays and a soft light and sound alarms are switched on. Similar approach is to be applied for all pollution sources parameters. As an example on pollution standards and guidelines are shown in Table 3. The international comparison of ambient air quality standards and guidelines as compared with recommendations of the World Health Organization (WHO). [3]

TABLE-1

CONVERSION EXAMPLE FROM PARTS PER MILLION TO PERCENTAGE

Parts Per Million (ppm)	*Percent (%)*
0 ppm	*0%*
5 ppm	*0.0005%*
50 ppm	*0.005%*
500 ppm	*0.05%*
1000 ppm	*0.1%*

TABLE-2

CARBON MONOXIDE SOURCES AND CONCENTRATION LEVELS.

Source	*Level of Carbon monoxide gas (CO)*
Natural atmospheric level	*0.1 ppm*
Average level in homes	*0.5 to 5 ppm*
Near properly adjusted gas stove in homes	*5 to 15 ppm*
Exhaust from automobile in city	*100 to 200 ppm*
Exhaust from a home wood fire	*5000 ppm*

TABLE 3

THE INTERNATIONAL COMPARISON OF AMBIENT AIR QUALITY STANDARDS

Pollutant	*WHO*	*EU*	*Australia*	*USA*	*Canada*
CO	*9*	*9*	*9*	*9*	*13*
N02	*21*	*21*	*30*	*53*	*53*
Ozone(O3)	*50*	*60*	*80*	*80*	*65*
SO2	*50*	*48*	*80*	*140*	*115*
PM 25 & PM 10	*25*	*50*	*25*	*65*	*30*
Lead (Pb)	*-*	*0.5*	*0.5*	*1.5*	*-*

Note: A dash (–) indicates that no standard or guideline has been established for a particular parameter

3. SYSTEM CONFIGURATION, HARDWARE DESIGN AND INTEGRATION

The required hardware for developing the suggested monitoring system design includes the following subsystems; industrial transmitters (sensors), final control elements, control unit with control algorithm, interfaces, communications and power supplies. In the next section, these subsystems and parts are to be designed, selected and integrated in overall system design.

3.1 Industrial transmitters, circuit designs and integration issues

The Industrial transmitters are used to detect, and read the next pollution types' sources; Air, Water, Light, Noise, and thermal Pollutions. Air pollutants are substances in the air that are very harmful to humans and the environment, such as the dust, unburned hydrocarbons (UHC), Sulfur dioxide SO2, Sulfur monoxide SO, nitrogen dioxide (NO2) ammonia (NH3), carbon monoxide (CO), Nitrogen oxides (NOx), namely nitrogen monoxide NO, dioxide dioxide (NO2), volatile organic compounds (VOC), ozone (O3) and carbon monoxide gas (CO), The Carbon Dioxide or (CO_2) and SOOT . [9] Water/ solution pollution in terms of the PH level, total organic carbon (TOC) and water Cooling/heating levels. Noise, chock and vibration pollution, at industrial facility, is caused from working machinery, heavy truck and traffic safety alarms. The comfort heat index (HI) also called humiture or the apparent temperature; is a measurement of how the temperature feels like to the human body at a given humidity, in outside ambient environment. When the air temperature is combined with both relative humidity and exposure (and stress). Can be indicator to avoid Heat illness including heat stroke, dehydration and illnessThe HI index has important considerations for the human body's comfort. It is calculated based on environmental data (air ambient environment temperature, relative humidity and stress). The expression for HI is applied only when temperatures exceed 27 degrees Celsius (80 degrees Fahrenheit). The carbon monoxide gas (CO), is a poisonous, tasteless odorless and colorless gas. Biologically, Carbon monoxide is the most common hazard type of fatal air industrial poisoning [9]. The MQ-2 Sensor, shown in figure 1(a), is selected for measuring (CO). For this sensor It is recommended that calibrating the detector for 200ppm CO in air and using Load resistance of about 10KΩ (5KΩ to 47 KΩ) increases circuit efficiency.[3]. Another options for measuring the carbon monoxide gas CO, is MQ-5 and MQ-7 gas sensors module from EleSof Technologies, shown in Figure 1(b). The Carbon Dioxide or (CO_2) is also, poisonous, tasteless, odorless, colorless gas and deadly at high concentrations. The largest source of CO_2 emission is the energy sector, (the combustion of fossil fuels). The MG-811 CO_2 sensor, shown in Figure 1(c), is selected to measure CO_2 emission levels. Unburned hydrocarbons (UHC), is the incomplete combustion of fuel (e.g. gasoline, diesel and wood) [10] [11], that is the part of fuel avoiding the flame zones and emitted from a combustor. UHC gases including propane, methane and nbutane. Different options are available to detect both the presence of UHC gases and to detect smoke (that is suspended particles resulting from combustion) . The MQ2 sensor shown in Figure 1(a) can be usedThe dust Particles level in the air monitoring can be accomplished using optical smoke and Dust Sensor GP2Y1010AU0F from Sharp and shown in Figure 2. (See also SOOT measuring in this section). Surrounding ambient Temperature level: different option are available to measure ambient Temperature; a) waterproof DS18B20 shown in Figure 3(a), b) analog LM35 sensor shown in Figure 3(b),. c) DHT11 Temperature and Humidity Sensor Module shown in Figure 3(d). Water temperature is expressing how hot or cold Water levels and rates are. The waterproof DS18B20 sensor, shown in Figure 3(a), can be utilized. Sulfur oxide (SO_x) is a term refers to many types of sulfur and oxygen e.g. Sulfur dioxide (SO2) and Sulfur monoxide (SO). Sulfur dioxide (SO2) is an invisible gas with nasty, sharp smell. It reacts easily with other substances to form harmful compounds. A suitable sensor for Sulfur dioxide is the analog and low power consumption Gas Sensor Module for SO2, shown in Figure 4. SOOT is the remaining non-combustible parts from the incomplete combustion of coal, oil, wood, or other fuels hydrocarbons. To measure SOOT, the newly Soot Particulate Partikel NOX Sensor, shown in Figure 5(a) can be utilized. Another option can be, Geekcreit® Nova PM Sensor SDS011 for Air quality detection Module shown in Figure 5(b).The last can also, be applied for dust levels measuring, The PH level of the water / a solution; pH can be defined as a measure of the acidic or basic (alkaline) nature of a solution. [12] The shown in Figure 6. PHE-45P pH Sensor Model can be applied to measure the pH levels of aqueous solutions in industrial and municipal process applications. Water quality Indicator; For this purpose different options are available, examples include: Turbidity level (measures the degree of water transparency (cloudiness or haziness) due to the suspended particulates presence. this Sensors is shown in Figure 7(a) Another sensor is, shown in Figure 7 (b), electric conductivity sensor to measure water salinity. Nitrogen oxides (NOx), namely nitrogen monoxide NO, dioxide dioxide (NO2), It results from the combustion of fuel atoms with air at high pressure and temperatures. For this purpose, different option available, a suitable option is air quality NH3, NOX, smoke gas sensor shown in Figure 8. For Noise, chock and vibration pollution in industrial environment, different option are available including: miniature Shock and impact sensor AW2T24TEL-4A1 shown in Figure 9(a). Another option is Model GLA-1/GLA-5 Analog Output Shock Sensor shown in Figure 9(b). A third option can be the Shock Switch Sensor Module shown in Figure 9(c) The comfort heat index (HI) also called humiture, two sensors are to be used to calculate the heat index the waterproof DS18B20 sensor shown in Figure 3(a) and DHT11 Temperature and Humidity Sensor shown in Figure 3(d). These two values will be used to calculate, by formula, the heat index. Illumination level can be measured using different ways; the simplest is using LDR in voltage divider circuit as shown in Figure 10.

3.2 Control unit and Control algorithm,

Due to the factory large space, and the need to spread sensors in different and remote locations in factory. the subsystems, and hardware components are suggested to be interfaced to each other via control unit wirelessly .The design is to be consisting of different control units; the main control unit with wireless communication unit, to which all wireless transmitters are to be interfaced. Each transmitter is to be equipped with transceiver model for sending readings wirelessly to main control unit.

Most suitable control unit, for industrial applications, is PLC, but customized control unit Microcontroller based boards, can be also be utilized. a suitable Microcontroller based board with more than 25 digital and analog ports and wireless communication, interfacing and transceiving capabilities, is Arduino due board shown in Figure 11(a). Arduino nano board, Figure 11(b), is suitable control unit for interfacing and communication between sensors control unit and actuators.

For system implementation, both continuous and ON/OFF control algorithms are suggested to be applied, to control the final control elements behavior and achieve desired optimal levels of industrial environment norms.

Fig. 8 *(a) MQ-2 Sensor*

Fig. 1(*b) MQ5 and MQ7 Sensors*

Fig. 1*(c) MG-811 CO2 sensors*

Fig. 1*(a, b, c) sensors alternatives for measuring CO*

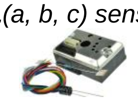

Fig. 2*(a) Smoke and Dust Sensor*

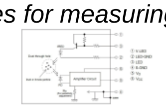

Fig. 2*(b). Sensor circuit diagram*

Fig. 2(*a, b). Smoke and Dust Sensor and circuit diagram*

Fig. 3*(a) Temp. waterproof DS18B20 sensor*

Fig. 3*(d) DHT11 Temperature and Humidity*

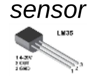

Fig. 3(*b) LM35 sensor*

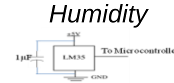

Fig. 3*(c) The circuit diagram of LM35 sensor*

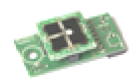

Fig. 4 *Gas Sensor Module for SO2*

Fig. 5(*a) The newly SOOT Particulate Sensor Partikel NOX Sensor,*

Fig. 5*(a) Geekcreit® Nova PM Air Quality Sensor SDS011*

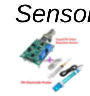

Fig. 6 *PHE-45P pH Sensor Model*

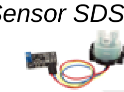

Fig. 7(*a)Turbidity level Sensors*

Fig. 7*(b) Electric Conductivity Sensor*

Fig. 8 *Air quality NH3,NOX,smoke gas sensor*

Fig. 9(*a) Shock sensor AW2T24TEL-4A1*

Fig. 9*(b) GLA-1/GLA-5 Model Analog Output Shock Sensor*

Fig. 9*(c) Shock Switch Sensor Module*

Fig. 10 *LDR based circuit for illumination level measuring*

3.3 Final control elements, Interfaces and Communication

The final control elements (Actuators), in the suggested monitoring system design, are the ones that are responsible for making adjustments changes in pollution environmental system, particularly; lighting system in factory, ventilation system (e.g. sucking fans), windows open/close, fire suppression system with fine water spray, sound and light alarms, displays, and other. Interfaces: a suitable choice for final control elements is to be of ON/OFF type. A suitable interface devices between control unit, power supply and these actuators are relays and drive circuits, example on which are shown in Figure 12(a)(b) The wireless Communication: due to the large factory space, the communication between sensors, control unit and actuators can be accomplished via wireless (Radio, Wifi, or GSM) Communication. A good option for wireless radio communication is utilizing, the shown in Figure 13(a), NRF24L01 transceiver module. An alternative option, HC-12 long range wireless communication module shown in Figure 13(b). A good option to broadcast signals is through internet with an ESP8266 Wi-Fi module, shown in Figure 13(c). GSM Module SIM900 shown in Figure 13(d), can be utilized to implement any function a cell phone can do, including; SMS text messages, make or receive phone calls and connect to internet. This model can be used to for communication to transmit data from transmitters, to main control unit and transmit control signal to final control elements, also alarm, displays and data about notifying supervisor and personnel in case of environmental state meets critical conditions.

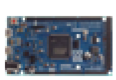

Fig. 11(a) the AT91SA-M3X8E Microcontroller based Arduino due board

Fig. 11(b) the ATmega328 Microcontroller based Arduino Nano board,

Fig. 12(a)high-30A current relays

Fig. 12(b) Drive circuit Geekcreit® L298N

Fig. 13(a), the NRF24L01 module

Fig. 13(b), HC-12 module

Fig. 13 (c) ESP8266 Wi-Fi module,

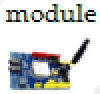

Fig. 13 (d)GSM Module SIM900 Arduino Shield,

4. SYSTEM PROTOTYPING

4.1 Mechanical structure design

The housing and outer design for components, transmitters and control unit, are to be developed for both, protection from industrial zone harmful effects and for fixing on desired sites. The control unit housing is suggested to be designed to enclose control unit with all related hardware components, also to include slots and fixtures to fix all components, and to interface all the next hardware; wireless communication system and drives, light and sound indicators, HMI, real time clock, cooling fan and others. Suggested control unit housing design for control unit, and placement of hardware, is shown in Figure 14. Suggested housing design for transmitters, are shown in Figure 15(a,b,c).

4.2 Subsystem and components building and interfacing,

Each transmitter unit is to be built, consisting of the following hardware components; transmitter itself, controller, wireless communication module, power supply, and interfaces. Example on building wireless temperature transmitter module is shown Figure 16(a). Example on building wireless HI index transmitter module is shown Figure 16(b). Each interface relay circuit is to be built consisting of the following hardware components; controller, wireless communication module, and power supply. Example on building relay interface circuit, for controlling alarm is shown Figure 16(C).

4.3 Integrated designs with of physical prototype

The overall environment monitoring system design, with all subsystems and hardware components, integrated to develop the overall system physical prototype, is shown in Figure 17.

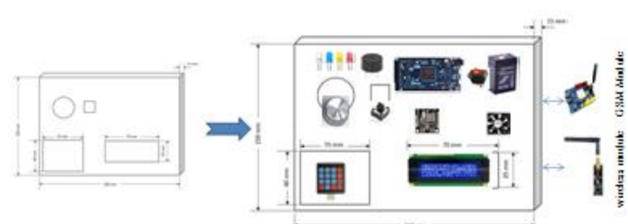

Fig. 14*(a) suggested housing design and components layout for main control unit*

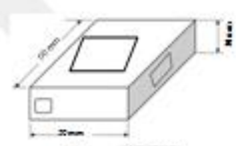

Fig. 15(b)

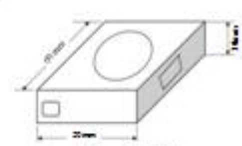

Fig. 15(c)

Fig. 14(b)(c) suggested transmitters housing design

Fig. 15(d) examples on transmitters' housing for protection and fixing

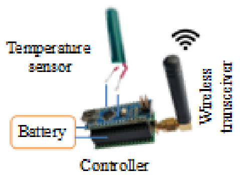

Fig. 16*(a) Example on building wireless temperature module*

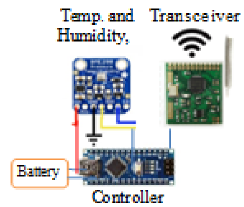

Fig. 16(*b) Example on building wireless HI index transmitter*

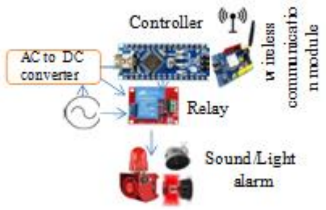

Fig. 16(*a) Example on building wireless relay interface circuit, for controlling alarm*

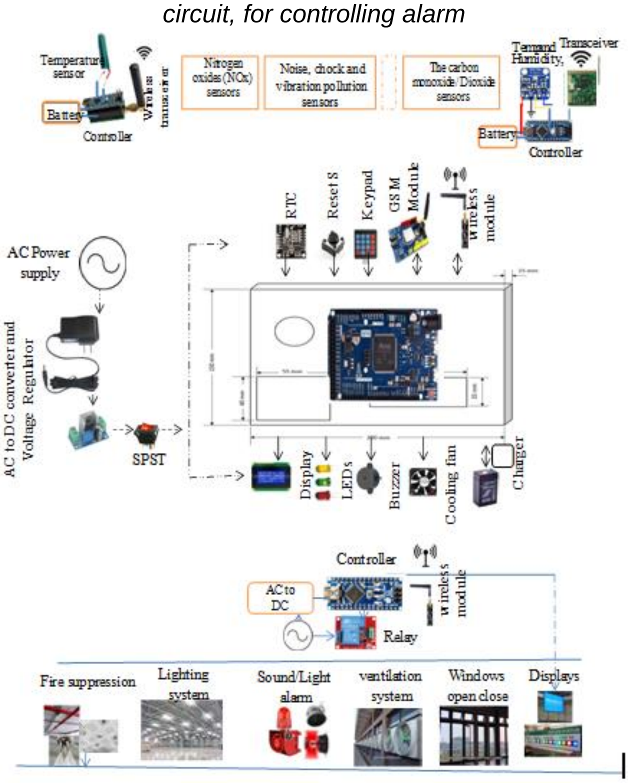

Figure 17 *The integration diagram of all hardware physical components in one overall monitoring system prototype*

4.4 Control algorithm representation

The acquired data readings, from industrial location site, are sent to the main control unit that is programmed with control algorithm developed to read, process and compare the value of each pollution parameter, if it is within the a acceptable range or note, take smart correction decisions, that in turn, send control signal to final control element to adjust the factory environment to meet desired levels, in addition, display readings on LCDs and notify supervisor and personnel in case of environmental state meets critical conditions. The algorithm flowchart representation is shown in Figure 17(a). in the wireless sensor module, for the Microcontroller to read, process and transmit data to the main control module, it first reads each sensor's reading and save it in specific matrix location, waits a finite time e.g. 2 ms, then read the next sensor's value, waits a finite time, and so on, when all values are read, it transmits data, waits a finite time, and repeat the process. In Figure 17(b), is shown the flowchart representation of the algorithm developed for data transmitting and receiving process. In this algorithm, for Microcontroller used in the main control module, to read the acquired signals transmitted wireless sensor module, process and transmit/receive decisions. First it identifies the wireless signal existence and strength, if yes, receive the transmitted data, waits a finite time, forward data in the control algorithm, and repeat the process. Both continuous and ON/OFF control algorithms are suggested, to control the final control elements behavior and achieve desired optimal levels of industrial environment norms.

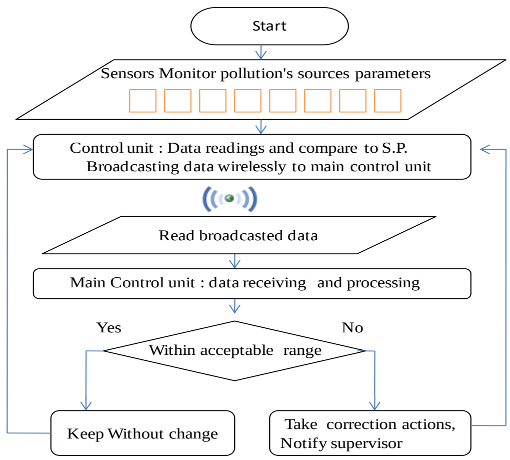

Fig. 17*(a) The algorithm flowchart representation*

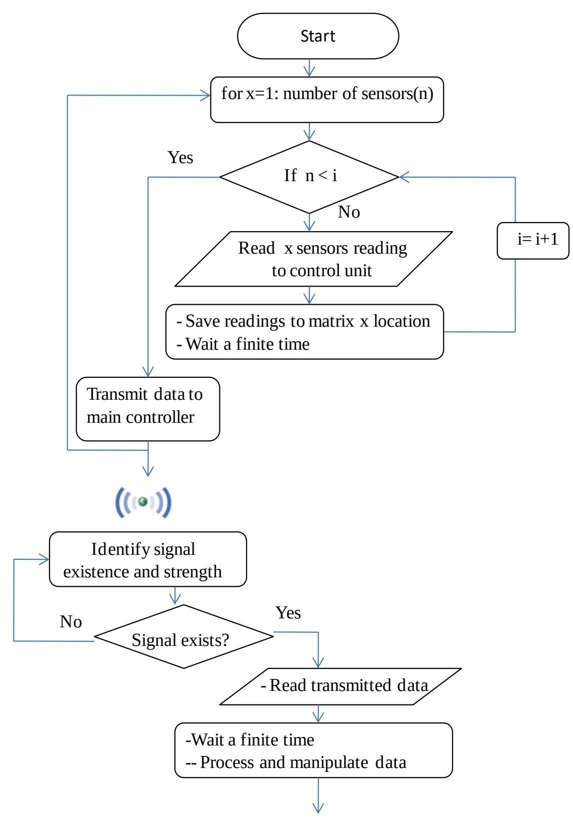

Fig. 17*(b) flowchart representation of the data transmitting and receiving algorithm*

5. CONCLUSIONS AND FUTURE WORK

In this work, is presented the theoretical design of real-time, smart, wireless industrial monitoring system for industrial manufacturing applications. The subsystems, components and circuits design selection, as well as, hardware integration was presented. The suggested design is developed as a dependable at low cost solution to achieving effective management of monitoring, tracking, assessing and registering pollution's sources parameters and conditions , to result in ensuring acceptable quality of factory's environment, maintain safety of personnel, Material and Machinery and finally to result in more optimized factory operation. As a future work, the environment monitoring system is to be developed physically. After that its operation will be tested and evaluated in real industrial environment, that was developed for, a metal processing operations like turning, forming, welding and similar processing operations.

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