Developed Intelligent Fire alarm system

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Abstract: The primary purpose of fire alarm system is to provide an early warning of fire so that people can be evacuated & immediate action can be taken to stop or eliminate of the fire effect as soon as possible. Alarm can be triggered by using detectors or by manual call point (Remotely). To alert/evacuate the occupants siren are used. With the Intelligent Building of the rapid development of technology applications, commercial fire alarm market demand growth, the key is to use the bus system intelligent distributed computer system fire alarm system, although installation in the system much easier than in the past , but still cannot meet the modern needs, the installation costs of equipment costs about 33% ~ 70. The suggested technique in Fire alarm system used the addressable detectors units besides using the wireless connection between the detector in zones as a slave units and the main control unit as the master unit. The system shall include a control panel, alarm initiating devices, notification appliances, and the accessory equipment necessary for a complete functioning fire alarm system. In the wireless fire alarm, individual units are powered by primary & secondary batteries for the communication.
[Hussam Elbehiery. **Developed Intelligent Fire alarm system.** *J Am Sci* 2012;8(8):1016-1024]. (ISSN: 1545-1003). http://www.jofamericanscience.org. 151

Keywords: Fire alarm systems, Fire Fighting systems, Building Management System, RF wireless, Smoke Detectors, Heat detectors, and embedded system

1. Introduction

Most victims of fire succumb to the smoke and toxic gases and not to burns. Fire produces poisonous gases that can spread rapidly and far from the fire itself to claim victims who are asleep and not even aware of the fire. Even if residents awaken, the effects of exposure to these gases can cloud their thinking and slow their reactions so that they cannot make their escape. This is why it is so crucial for you and your family to have sufficient warning so that you can all escape before your ability to think and move is impaired. In addition, more than half of fatal fires in homes occur when people are asleep (**Ananthram,et al , 2007)**

The fire alarm system can also be integrated with AC supply, access control, fire fighting systems, Building Management System (BMS).....etc. To indicate the area where fire exist fire indicating/fire alarm panels are used. So far, cables were used to integrate all the device of fire alarm systems, these cables carried the power & communication.

When we have unique address; therefore all these devices can be easily identifiable, controllable & networkable as required by the end users. Subsequent detector installation saves not only the cost of cabling, but also the time-consuming work associated with mounting & wiring even under difficult environmental conditions. The detector most suitable for the corresponding usage area is simply placed on the wireless base and/or wireless interface. **(Ananthramet al 2007),** (John, 2001)

Wireless fire alarm system should meet the current requirements, easy to install, fast and cheap, without wiring of the building damaging the surface of the smallest on the functional changes in the characteristics of the easy adaptability. **(. Nederstigt, 1990)**.

Wireless automatic fire alarm system is a typical multi-sensor type of event-driven wireless sensor network (WSN), but with its special requirements **(Ananthram, Qing, 2007):** :

- System reliability, credibility, we must consider the indoor multi-path scattering, echo, interference, interruption, to deal with collision detection;
- System works a minimum of 5 years life cycle;
- Switchboard and must be two-way communication between detectors;
- Alarm signal transmission time must be within 10 seconds;
- System interference and failure detection time to less than 100 to reflect seconds.

To the design of high reliability, strong anti-interference ability of automatic fire alarm system, its requirements are:

- When a fire occurs, to speed detection alarm and fire detection occurred in specific locations (specific address coding);
- The investigation confirmed, can be timely informed of the fire department in fire fighting;

- System itself should be its own fault detection features, such as under-voltage alarm and system self-test function to ensure the automatic alarm system in good condition;
- More high anti-interference ability of the system to prevent False Alarm system;
- Relatively long life cycle of the system.

2. Alarm Systems

The most basic alarm system is designed to only be initiated manually. This is a local warning system similar to the type installed in schools or theaters, and the signal alerts occupants of the need to evacuate the premises. While alarm standards have traditionally called this type a local system. A wide variety of optional features are available to expand the capabilities of an alarm system. Automatic fire detection devices may be added, allowing the system to sense the presence of a fire and to initiate a signal (www.eurospanbookstore.com).

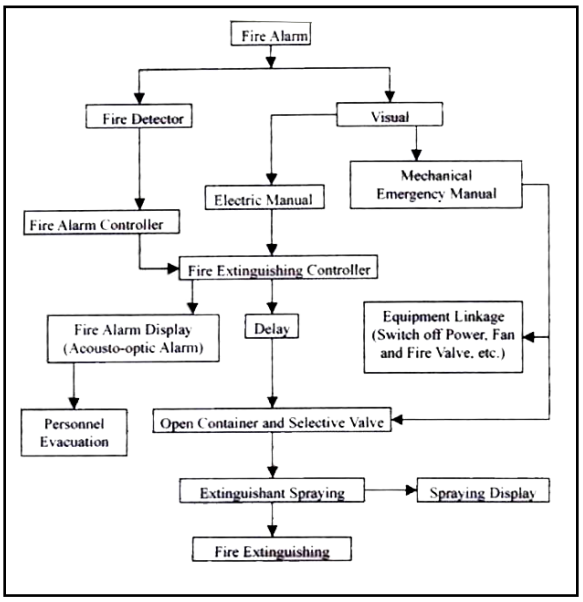


Figure 1. Fire Alarm system overview

There are four basic types of automatic alarm-initiating devices are designed to detect, smoke, heat, fire gases, and flame. (Vijay, Elliot, 2006)

2.1 Smoke Alarm

Also often known as smoke detectors, these devices are one of the best early-warning devices of a fire. They are designed to sense low levels of smoke and sound an alarm. Some smoke alarms are what are known as "single station," or stand-alone devices. If they go into alarm, only the one detector is activated, alerting people right around it. Some detectors may be connected to the building's fire alarm system. When this detector senses smoke, it may either sound an alarm in the room, or send a signal to the building fire alarm system.

It is important that smoke alarms are located in areas where they cannot be set off accidentally by steam from showers or from cooking smoke. Smoke detectors have two main types: Photoelectric Smoke Detectors, and Ionization Smoke Detectors.

2.2 Heat Detectors

In some areas, such as kitchens, smoke detectors would be going off all of the time. Heat detectors, which react at either a fixed temperature, or when heat is rising at a certain rate, provide detection in these areas. Some smoke detectors have heat detectors as part of their design to provide dual protection. Heat detectors have four main types:

- Fixed Temperature Heat Detector,
- Rate of Rise Detector,
- Rate Compensation,
- Line type detectors.

2.3 Fire Gases Detectors

When a fire burns in a confined space, it changes the makeup of the atmosphere within the space. Depending on the fuel, some of the gases released by a fire may include the following:

- Water vapor (H2O),
- Carbon dioxide (CO2),
- Carbon monoxide (CO),
- Hydrogen chloride (HCL),
- Hydrogen cyanide (HCN),
- Hydrogen fluoride (HF),
- Hydrogen sulfide (H2S).

2.4 Flame Detectors

That is the stage which after the smokes or gases and has the highest degree of dangerousness. There are three basic types of flame detectors (sometimes called light detectors):

- Detecting light in the ultraviolet wave spectrum (UV detectors),
- Detecting light in the infrared wave spectrum (IR detectors),
- Detecting both types of light.

3. Fire Alarm System Structure Design

There are three main designs for the fire alarm systems (Ananthram, Qing, 2007)::

- Conventional Analogue Fire alarm system,
- Addressable Analogue Fire alarm system,
- Wireless Fire alarm system.

3.1 Conventional System

The main bone of this system is the Circuit board. The single circuit board contains power supply, control, and initiating and notification circuitry. Designated outputs occur when initiating signals are received. This system is not expensive but not addressed beside it is a wired System. The conventional fire alarm systems have many features as as (**Liu, 001):**):

- Two state Detector (Normal state, alarm state),
- Two wire connection,
- Separate indicator in the main fire alarm panel,
- Smoke detector, and Heat Detector,
- Manual Break Glass can share the same circuit as detectors,
- Removal of any detector shall not prevent from the operating of any break glass.

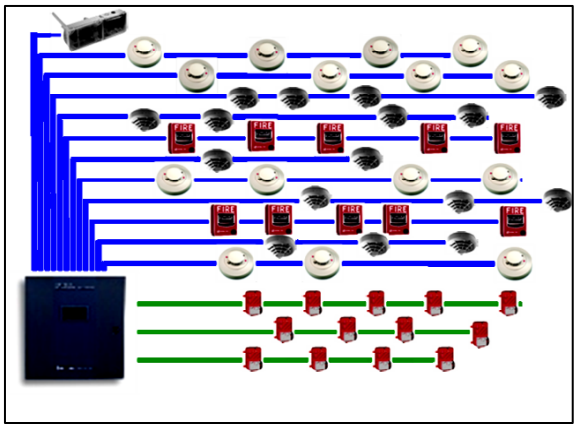
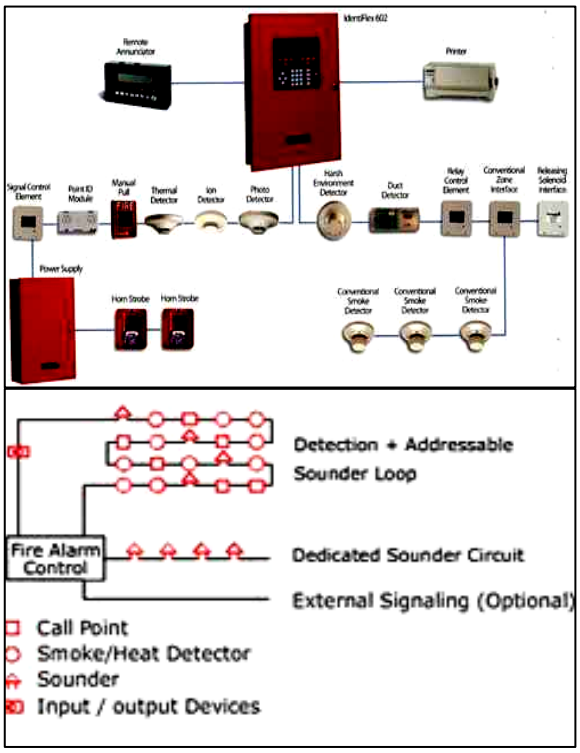


Figure 2. Conventional system circuit

3.2 Addressable System "Multiplexed"

Each device (detector, pull station…etc.) has a unique number assigned to call the address for reporting alarms and troubles. Addressable devices transmit an electronic message back to the Control unit representing their state (Normal, Alarm, Trouble) when polled by the Control Unit. The addressable systems have many features as features as (**Liu,., 2001):**Addressable detector, call points, signals which is individually identified by the control panel,

- Addressable detectors shall be connected via two wire connection such that the connection of the both wire to form a loop in order to provide circuit integrity,
- Addressable detector is addressed through soft addressing or dip switch,
- Multiplex communication technique allows each detector to independently signal it status back to the control panel,
- Addressable system can also handle output device on the zone circuit, where the address massage can be command instruction to an output device (on/Off) Example: Sounder Module, Switching On/Off Relays,
- Interface module is a device that is used to interface the conventional alarm system and the addressable system.



(a) (b)

Figure 3. Addressable system (a) Circuit (b) Structure

The sensors give an analog output signal representing the value of the sense phenomenon. The output of an analogue addressable detector is variable and it is proportional representation of the sense effect of fire, smoke and flame. Transition of this output from a detector is usually in a form of analog current to the control panel that tells the panel what condition of the room being sense monitored. In order for an analog addressable system to raise alarm, the analog value output by the detector must be in the alarm condition (above the alarm threshold) for a period equal to time taken to complete three successive address sequences (6 sec).

The addressable system has the advantages that it is Addressed system, Easy Install, and accurate system. But historically, addressable systems have tended to be complicated to configure, and cost between 50% to 100% more than a conventional equivalent therefore we could take that as a disadvantage beside it is a wired system. Three basic conditions to be interpreted by the Control Panel Arthur, 2003):

- Alarm Condition - Full Scale building evacuation,

- Pre Alarm Condition - Inspection and search for source,
- Fault - Warning need to be repair.

3.3 Conventional vs. Addressable Fire Alarm systems

There are several differences between conventional & addressable fire alarm systems. These differences include;

- Addressable fire alarm systems give information about individual detectors, whereas conventional systems only give information about specific circuits (zones).
- Addressable systems allow a courtesy text label to allow easy identification of any event. For instance detector 1 may be given the label "Bedroom 1″.
- Most addressable systems allow an early "pre-alarm" warning, which allows the responsible person to investigate potential alarms before the system activates its sirens.
- Many addressable systems can alter the alarm threshold of the detectors, in order to meet the needs of different environments in different areas of the system.
- Addressable systems are usually wired in a loop. Conventional systems are usually wired as radial circuits.
- Addressable systems usually have a real time clock & event log to record system events.
- Larger addressable systems usually have the ability to use sophisticated programming options to operate certain outputs only with specific events.

3.4 Intelligent System "Analog data transfer"

Intelligent fire alarm systems always are Addressable System, Can provide sensitivity data for each detector, Employs Drift Compensation (self calibration) in its detectors, Shortened installation schedule, Greater device supervision, and Superior troubleshooting capability. The intelligent fire alarm systems have many features as as **(Raul, et al , 2009), (Terry, John, 2002)**;

Lower wiring costs,

- Always an Addressable System,
- Integrated Networkability,
- Rapid and direct identification of fire threat.

4. Wireless Fire Alarm System (Suggested technique)

As in recent years in human micro-electro-mechanical systems, wireless communications, digital electronics has made great achievements, making the development of low-cost, low power consumption, small size, and short-range multi-sensor communication possible. Wireless sensor network and artificial intelligence integration can greatly enhance the reliability of fire alarm system **(Juan, 2009).**

This system consist of a central control panel to which smoke alarms and heat detectors are connected, along with bells or horns that are activated when the system triggers an alarm. Other sensors associated with the burglary functions connect to doors and windows or monitor rooms for motion or body heat. The control panel operates from wall power but also usually contains an emergency battery which can operate the system for about 24 hours during a power outage.

The basic requirements for the number and locations of alarms are exactly the same as with the self-contained alarms discussed previously. The difference is that fire alarm system gives more flexibility to locate additional alarms and additional bells or horns (or flashing lights, should a person in the building be hearing impaired).

The sensors give a digital output signal representing the value of the sense phenomenon. The output of a digital conventional detector is variable and it is proportional representation of the sense effect of fire, smoke and flame. Transition of this output from a detector is in a form of digital current to the control panel that tells the panel what condition of the room being sense /monitored.

4.1 Wireless importance

RF wireless technology is a short distance, low-complexity, low-power, low data rate, low-cost two-way wireless communication technologies, mainly suitable for the field of automatic control and remote control can be embedded into various devices, at the same time support the geo-positioning function.

With increasing distance communication, equipment complexity, power consumption and system costs are on the rise. Compared with the existing wireless communication technologies, RF wireless technology will be the lowest power consumption and cost of technology. But low data rate and communication range of the smaller features of RF wireless technology also determines the flow of data is suitable for carrying smaller business. Generally speaking, there is an importance for the wireless technology for (Carlos, 2009):

- Ability to interconnect without wires,
- Install in minutes, anywhere in the homeless cost than re-wiring,
- Mobility & Adaptability.

4.2 System hardware design

The suggested hardware design mainly consists of; Wireless Main Unit Control Panel (Main fire Alarm Control panel), Wireless Slave Unit Control Panel, Analogs Conventional Detectors, Wireless Manual Call Point/Remote Control Unit, and Analogs Siren connected with dry contact.

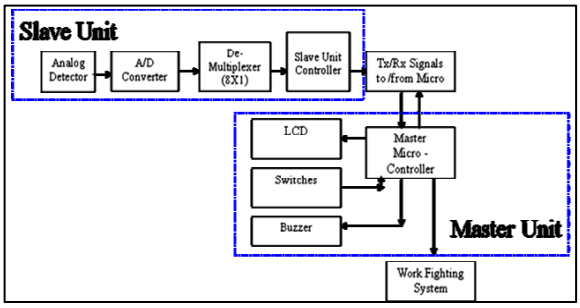


Figure 4. Wireless Intelligent Fire Alarm system block diagram

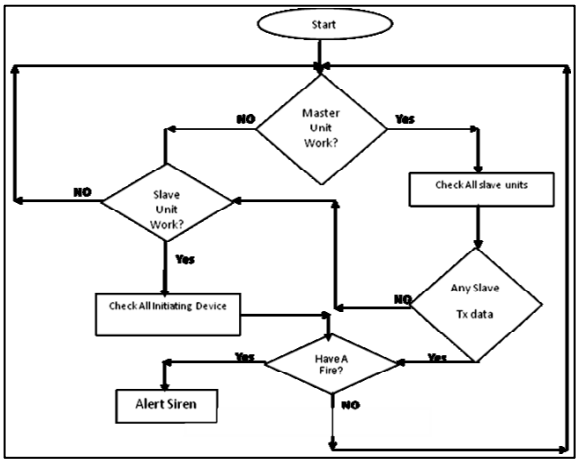


Figure 5. Wireless Intelligent Fire Alarm system flowchart operation

Deeply the system hardware design includes mainly the data acquisition system and data-side constitutes the receiving end, sensor data acquisition, MCU and wireless transceiver chips and so on. Wireless transceiver chip with the MCU through the SPI bus to connect the two constitute a wireless transmission module.

Data receiver uses the same wireless transceiver modules, and the use of asynchronous RS232 serial communication with PC. Its function is equivalent to an access point, on the one hand the host side to the data acquisition control signals sent by wireless means to launch out, on the other hand to receive the data collection and upload to the host.

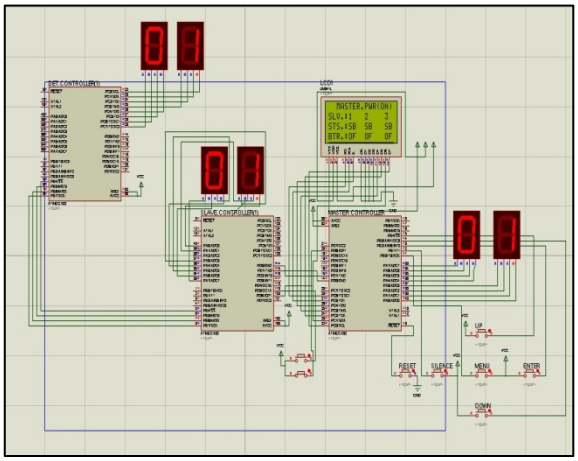
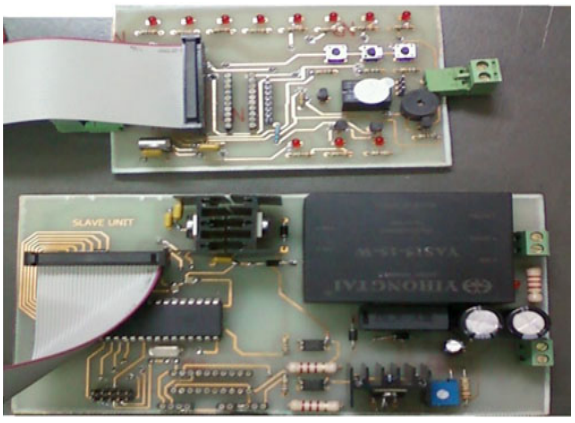


Figure 6. Suggested Developed Intelligent fire alarm system simulation by Proteus



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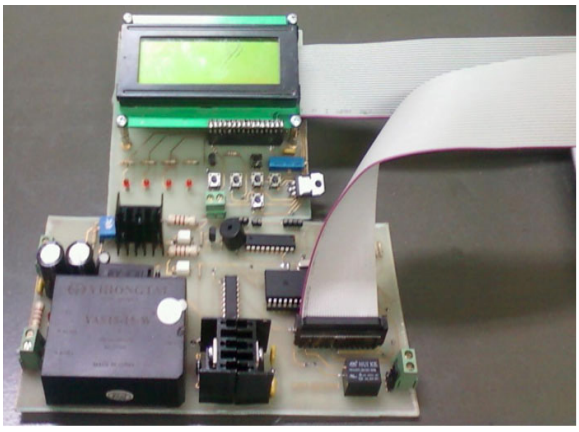
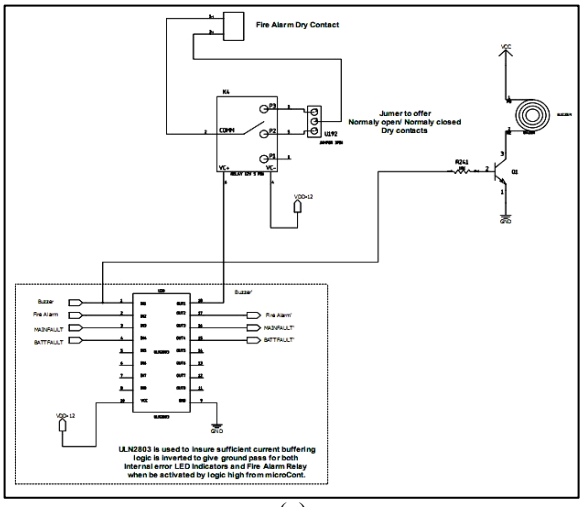


(b)

Figure 7. Fabricated circuits boards (a) Slave Unit (b) Master Unit



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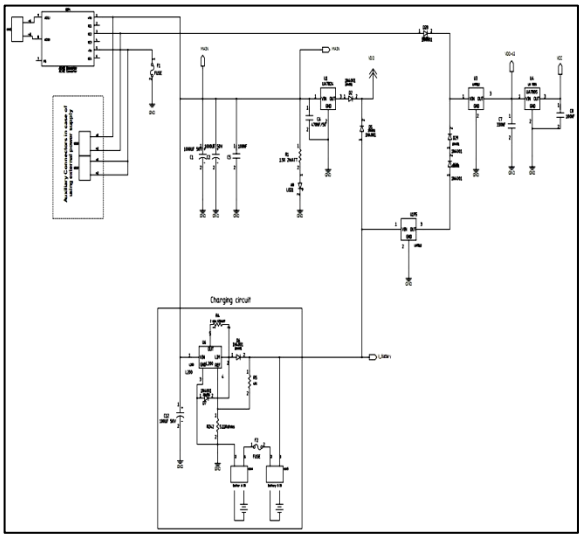

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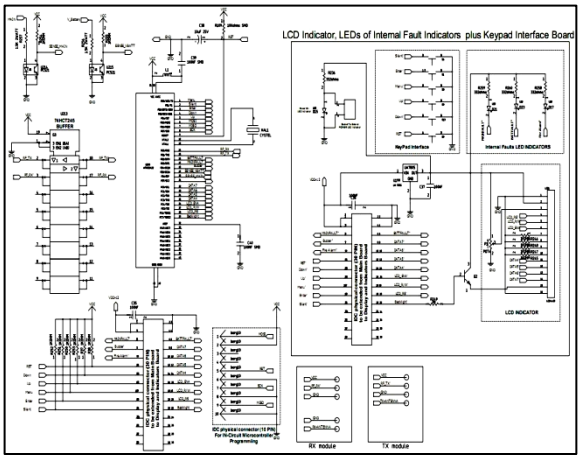
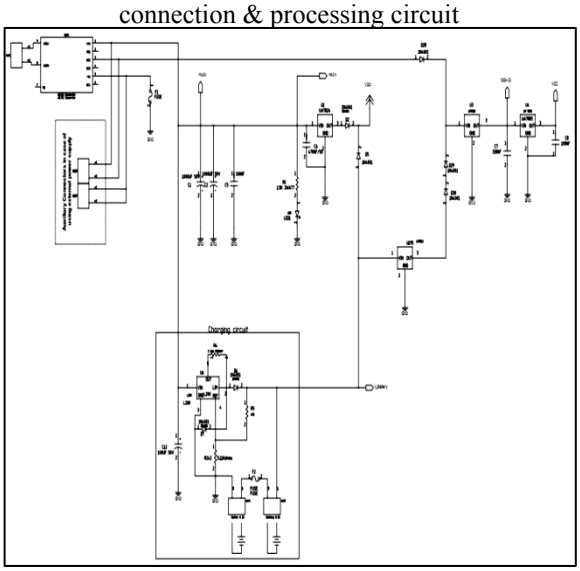


(c)

Figure 8. Master unit schematic circuits Relay circuit (b) Power supply circuit (c) Sensor connection & processing circuit



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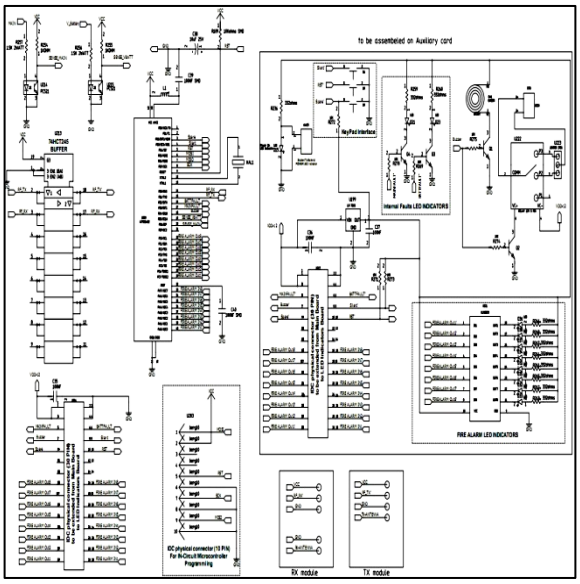

(b)

Figure 9. Slave unit schematic circuits (a) Power supply circuit (b) Detector connection circuit

4.3 Suggested system functionality

When the sensor signals to test fire, the fire control center to carry out the calculation of these data processing and statistical assessment. Signal to determine the principle of fire is not simple non-guidelines, and taking into account the needs of a number of other factors. Pre-determined in accordance with the rules of these data into a suitable

indicator of the police action, the corresponding pre-warning issued.

When a fire alarm condition is detected by one of the system alarm initiating devices, the following functions shall occur:

- System alarm LED shall flash.
- Local sounding device in panel shall be activated.
- The LCD display shall indicate type of device, custom label location label and point status alarm condition.
- Automatic programs assigned to alarm point shall be executed and associated indicating devices and relays activated.

When any trouble condition is detected the following functions shall occur:

- Local sounding device in panel shall be activated.
- The LCD display shall indicate the type of trouble and custom label location associated with the trouble condition and its location. Unacknowledged alarm messages shall have priority over trouble messages. If such an alarm is displayed, then trouble messages shall not be displayed.

Activation of the signal silence switch shall cause appropriate notification (indicating) appliances and relays to return to normal condition. Selection of notification appliance circuits and relays silenced by this switch shall be fully programmable.

Activation of system reset switch shall cause electronically latched initiating devices or zones, as well as associated output devices and circuits, to return to normal condition after sixty seconds of alarm. If alarm conditions exist in system after system reset switch activation, system shall then re-sound alarm conditions as indicated hereafter.

4.4 Power Requirements

- The fire alarm control panel shall receive 220 VAC power, 60 Hz.
- There will be a converter circuit which converts the 220 VAC to regulated 12v dc and 5 v dc.
- There will be a rechargeable battery includes its regulated output voltages (12 Vdc and 5 Vdc) in case of the AC power is lost.
- System shall automatically transfer to standby batteries upon power failure. Battery charging and recharging operations shall be automatic. Batteries, once discharged, shall recharge at a rate to provide a minimum of 70 percent capacity in 12 hours.

In order to achieve the practical number of sensors to reduce the complexity of the network, reducing overall power consumption of the network, based on each fire sensor nodes or work on sleep and the use of low-power channel monitoring in order to save power consumption sensor node and to refuse to accept the request to visit the illegal connections, greatly reduced the access node FLCH the probability of collisions when the information has greatly increased the capacity of sensor networks. (Kay, Dwayne, 2005), (Robert, 2008)

4.5 System Capacity

- The main fire alarm control panel capable of transmit/receive more than one slave unit,
- The slave unit capable of 40-conventional devices (Five Fire Zones).
- The system shall be programmable, configurable.

4.5.1 System Display

- The design of the CPU shall provide for a configuration with the 64-character display,
- The 64-character display shall provide all the controls and indicators used by the system operator
- The system shall support the display of battery charging current and voltage on the LCD display.

5. Research epitomization

- Addressable control panel like a 5 zone conventional fire alarm control panel but include wireless system procedure,
- 40 addressable Detectors,
- Easy program,
- Uses standard wire,
- Use any type of conventional detector,
- 220VAC power input with charging circuit beside an existence of emergency battery,
- Faster response time requirements, the detector states transmit to master directly in a few second,
- Transmits the status (normal, open, or alarm) of all detectors one-to-other,
- Smoke detectors must not be installed in the same room as the control panel,
- 3.9k EOL resistance,
- Class B supervised regulated,
- Audible device can be set in any place and worked from master unit or slave.

This design is comparable to two systems exist recently in the market;

- SHP-PRO® Fire Alarm Protection System , produced by Fike's company, and
- IntelliKnight 5600 Single Loop Fire Alarm, produced by Honeywell's company.

The suggested system has many advantages than the existed system in the market clarified in the following:-

Table 1. Specification comparison between suggested system and the existed systems in market

Item	Suggested system	SHP-PRO(Fike)	IntelliKnight (Honeywell)
System description	Addressable control panel like a 5 zone conventional fire alarm control panel but include wireless system procedure,	Fike's SHP-PRO conventional fire alarm system	The 5600 is an addressable control panel that has the characteristics of a 5 zone conventional fire alarm control panel.
System Types	Wireless, intelligent, addressable and conventional detectors use	Conventional or addressable system	Conventional or addressable system
No. of devices	(40)	(20)-to(25)	25
Detector types	Any conventional detector type	Fike's conventional detectors	Honeywell's addressable detectors
programming tool	Easy programming by STK-200 tool	All configuration variables can be assigned using C-LINX software.	Jump Start Auto Learn Process
Applications	used for fire sprinkler, sprinkler pre-action deluge and most conventional fire alarm applications,	used for fire sprinkler, sprinkler pre-action deluge and most conventional fire alarm applications,	All applications
Input power	220VAC power input	Selectable 120 or 240VAC power input	
Notification Power	….	Power limited for zone module is 90mA per module.	2.0A @ 24 VDC
Battery Charging Capacity	….	Up to 90 hours of standby power	7.0 – 33 AH
Standby Current	…..		Standby Current: 135 mA
Alarm Current	….	Maximum Alarm Current for zone module is 2.1mA	Alarm Current: 220 mA

6. Conclusion

The primary advantage of a home fire alarm system is increased reliability and the ability to place alarms and bells exactly where needed. However, the reason most people have them is that they wanted a burglar alarm system and the cost of adding fire alarm features to a residential burglary system is relatively small.

Another advantage is that they are the only way to obtain remote monitoring services. This becomes important in cases where family members may not be capable of escaping from a fire without assistance. For example, if you have an older or physically impaired person in your home and a fire started when no one was home to assist that person, alarms alone might not be enough to assure their safety.

Fire wireless sensor platform of hardware and software design for the entire system development and application is essential, as the bottom of the whole system support to the miniaturization of its inevitable, highly integrated, network-based, energy-saving and intelligent direction, nearly few years, with the declining cost of computer and microprocessor to reduce the size, development and construction of intelligent wireless fire alarm system will have broad application prospects. Engineering test results fully demonstrated the technical feasibility and the effectiveness of the realization. (Ananthram, Qing, 2007).

Fire alarm systems that provide remote monitoring services can also be used to provide medical alert services. Here a person with health problems who lives alone carries a radio transmitter that can trigger the system in case they need assistance. Signals received at the monitoring station are identified by type (fire, burglary, medical alert) so that the proper response can be made.

Finally, we can say by applying the suggested technique in Fire Alarm wireless Intelligent system that this system has advantages of; Low cost System, Addressable system, Integrated networkability, Conventional detector used" lower wiring costs". Also it has little disadvantages of; System will be failed if the slaves' unit network has a failure. (Robert, 2008)

Acknowledgement

This work was supported by faculty of engineering - Benha University - Cairo/Egypt. I would thank kindly Assoc. Prof. M. Tarek Elewa his supporting this research.

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