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Smoke & Fire Detection Control System with Heatmap Analysis

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Abstract : A smoke/Fire detector is a fire protection device that automatically detects smoke and also gives us warning. The project entails the design and engineering of a smoke and Fire detector unit and network.The automatic smoke & fire detection and control system is embedded electronics based smart system which is used to take control over smoke as well as fire in case of emergency.With the help of various feedback sensor this system is able to control exhaust fan and water sprinklers in case of fire catchup and smoke. Such automation & security system is very useful in places such as colleges, schools, offices, bank, industry etc.The previous research on this technology shows various types of system for fire/smoke control but none of them has multiple sensors, real time control and data visualization. In our system we have used various sensors as fire sensor, smoke detection sensor, and NTC thermistors.With the help of advance embedded firmware/software design this system is able to perform multiple tasks such as controlling smoke, controlling fire, monitoring thermistors, indication, communication etc. all in real time with the help of interrupts, timers, etc.To control, configure, and drive all these input and output devices, an 8-bit AVR microcontroller (ATmega8A) is used.This system is able to sense , monitor , analyze and control smoke and fire in case of emergency.for monitoring analysis and visualization we will design computer application / software for all GUI stuff**.**
Keywords : Smoke and Fire detector, AVR Microcontroller(ATmega8A),NTC thermistors, GUI

1. Introduction

The automatic smoke & fire detection and control system is embedded electronics based smart system which is used to take control over smoke as well as fire in case of emergency. With the help of various feedback sensor this system is able to control exhaust fan and water sprinklers in case of fire catchup and smoke. Such automation & security system is very useful in places such as colleges, schools, offices, bank, industry, etc. The previous research on this technology shows various types of system for fire/smoke control but none of them has multiple sensors, real time control and data visualization. In our system we have used various sensors as fire sensor, smoke detection sensor, and NTC thermistors.All these transducers/sensors are aimed to sense various physical quantities such as heat, light, flame, smoke, etc. in real time. For smoke control this system uses one exhaust fan and for fire control it is having one water pump.

For indication purpose this system also has multiple color LEDs (Light Emitting Diodes) which are used to indicate various things such as system status, alert status, error, power, etc. It is also having one buzzer for beep/sound indication which can beep in multiple patterns and for multiple time in case of emergency. Apart from control & indication sub-system it uses multiple NTC thermistors (Negative Temperature Coefficient) for temperature monitoring and heatmap visualization & analysis. For visualization, monitoring, & analysis of sensory data we have designed one Java based GUI computer application/software which communicates with our system via USB-to-TTL converter and shows data on Graphical User Interface (UI/GUI) panel [Front Screen]. The GUI shows various things such as raw sensor data, smoke/fire status, fan or pump status, temperature, and heatmap of particular room. With the help of

advance embedded firmware/software design this system is able to perform multiple tasks such as controlling smoke, controlling fire, monitoring thermistors, indication, communication, etc. all in real time with the help of interrupts, timers, etc.To control, configure, and drive all these input and output devices, an 8-bit AVR microcontroller (ATmega8A) is used to which all i/o devices, driver circuits, & sensors are interfaced. This microcontroller act as heart of the system which delivers various types of signals (analog, digital, etc.) from various devices to one another. This microcontroller has multifunctional GPIOs (General Purpose Inputs & Outputs) few of them are also capable of sensing analog signals from sensors such as smoke sensor, fire sensor, NTC, etc. with the help of inbuilt ADC (Analog to Digital Converter). For communication between system and host computer we have used USB-to-TTL converter which uses standard UART interface for microcontroller, this is connected to dedicated GPIO [Rx, Tx] for UART (Universal Asynchronous Receiver & Transmitter) communication at fix baud-rate of 57600 (57600 bits/s). The drivers for various peripherals such as UART, ADC, timers, etc. and various algorithms such as SHH model, mean avg., etc. and also the complete flow of system is programmed inside this 8-bit microcontroller using embedded C++ and dedicated software/IDE.

1.1 Major Components

1.1.1. AVR Microcontroller (ATmega8A)

The ATmega8 is a low-power CMOS 8-bit microcontroller based on the AVR RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega8 achieves throughputs approaching 1 MIPS per MHz, allowing the system designed to optimize power consumption ver- sus processing speed.The high-performance, low-power Microchip 8-bit AVR RISC-based microcontroller combines 8 KB ISP Flash memory with read-while-write capabilities, 512B EEPROM, 1 KB SRAM, 23 general purpose I/O lines, 32 general purpose working registers, three flexible timer/counters with compare modes, internal and external interrupts, serial programmable USART, a byte-oriented Two-Wire serial interface, 6-channel 10-bit A/D converter (8-channel in TQFP and QFN/MLF packages), programmable watchdog timer with internal oscillator, SPI serial port, and five software selectable power saving modes. The device operates between 2.7-5.5 volts.

By executing powerful instructions in a single clock cycle, the device achieves throughputs approaching one MIPS per MHz, balancing power consumption and processing speed.

1.1.2 Smoke/Fire Detector

A smoke detector is an electronic fire-protection device that automatically senses the presence of smoke, as a key indication of fire, and sounds a warning to building occupants. Commercial and industrial smoke detectors issue a signal to a fire alarm control panel as part of a building's central fire alarm system.smoke detector, device used to warn occupants of a building of the presence of a fire before it reaches a rapidly spreading stage and inhibits escape or attempts to extinguish it. On sensing smoke the detectors emit a loud, high-pitched alarm tone, usually warbling or intermittent, and usually accompanied by a flashing light.

1.1.3 NTC Thermister

NTC stands for "Negative Temperature Coefficient". NTC thermistors are resistors with a negative temperature coefficient, which means that the resistance decreases with increasing temperature. They are primarily used as resistive temperature sensors and current-limiting devices. The temperature sensitivity coefficient is about five times greater than that of silicon temperature sensors (silistors) and about ten times greater than that of resistance temperature detectors (RTDs). NTC sensors are typically used in a range from −55 to +200 °C.An NTC thermistor is a thermally sensitive resistor for which the resistance exhibits a large, precise and predictable decrease as the core temperature of the resistor increases over the operating temperature range.Negative temperature coefficient of resistance thermistors, or NTC thermistors for short, reduce or decrease their resistive value as the operating temperature around them increases. Generally, NTC thermistors are the most commonly used type of temperature sensors as they can be used in virtually any type of equipment where temperature plays a role.

1.2 Literature Survey

A Smoke Detector Algorithm for Large Eddy Simulation Modeling Richard J. Roby Stephen M. Olenick Wei Zhang Douglas J. Carpenter Michael S. Klassen It has been well established in the fire protection engineering community that smoke detectors present an entry resistance to smoke-laden flows. Entry resistance means that the smoke concentration outside the detector may not correspond to that at the sensor located inside the housing. . Different fire scenarios can lead to low velocity flows at the smoke detector locations where the simple approach of Heskestad will not apply. The smoke detector activation algorithm is integrated with FDS and the results are dependent on proper use of FDS. [1]

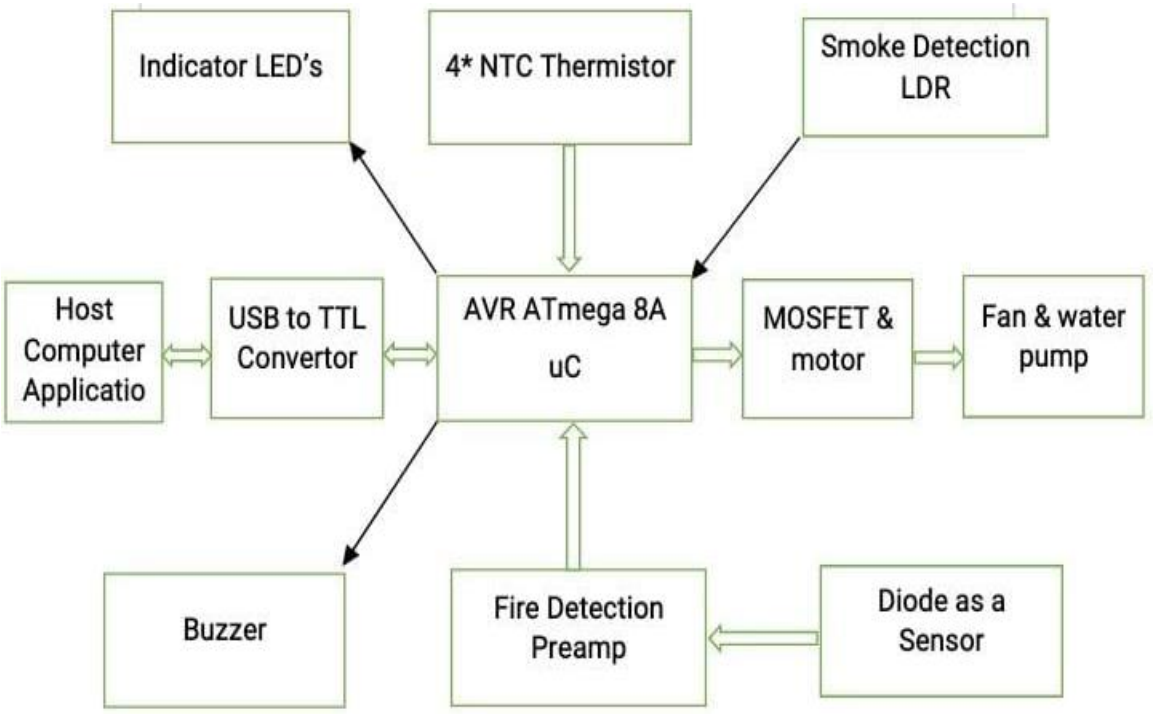
Othman O. Khalifa1, A. Albagul2, Sheroz Khan1, Mohd Rafiqul Islam1, Noruzaihan Mod Usman1 1Electrical and Computer Engineering, Kulliyyah of Engineering, International Islamic University Malaysia, P.O Box 10, 50728 2High Electronics Institute, Beniwalid, Libya This system operated by indicating an increase temperature above the safe limit in the room where it was fixed. Before scientists knew how to capture ionizing molecules in a small enclosed space, they actually used an open and close electrical system along with a wedge of butter to detect fires and heat. It consists of two plates or electrical circuits with a wedge of butter between them. When the heat of the room became overwhelming and the temperature is over the safe limit, the butter would melt. Both circuits collapse onto one another and then initiating the alarm. The first battery-operated home smoke detector was 409 .[2]

According to the primary purpose of fire protection system is to protect human life, and in case of most building, the secondary protection consideration is property, the easiest way of fire extinguishing is the fire detection system, so the speed at which the fire is detected is very vital because the faster the fire is detected the better the chances of the fire being extinguished thereby reducing damages of properties. It's very difficult to control and monitor fire in a very high and spaced building hence, intelligent fire detection system are important. Therefore, fire detection systems which are self-monitoring and have the ability to initiate both audible and visual warning in a spaced building are required.[3]

Gabriel Roque,Vladimir Sanchez Padilla,LPWAN Based IoT Surveillance System for Outdoor Fire Detection the authors in presented the integration of data regarding fire risk assessment, fire detection, safety situation awareness, among other aspects for the displaying of alerts through smartphones for underground miners optimize an evacuation process. Their proposal consisted of a wireless network system

structure based on an IEEE 802.11 backbone, composed of several Wi-Fi nodes for communication with a surface control center and the fire safety system. They used smart technologies for a continuous information flow for the improvement of fire safety, detection, and evacuation procedures as a framework for this type of industry. [4]

2 Block Diagram



3. Working

This system consists of various passive as well as active components, and devices such as resistors, capacitors, diodes, transistors, LEDs, buzzer, microcontroller, LDO regulator IC, etc. All of these devices are connected to each other as per the circuit design. The circuit is divided into multiple parts/units for better understanding. The DC power supply unit consist of an external step-down 220v-12v transformer whose secondary is connected to on-board full bridge rectifier built with diodes (D1, D2, D3, D4) whose job is to convert the step-down 12v AC from transformer's secondary into pulsating 12v peak DC. This pulsated DC is then feed into one 1000uF electrolytic capacitor (C1) which acts as a LPF (Low Pass Filter) this results in smooth 12v DC output with very small variations in voltage (around 5-10%). After converting AC into smooth 12v DC a 5v Voltage Regulator IC (U2-LM7805) is used which converts its input 12v DC into regulated 5v (mostly constant) output. This 5v is then used by various low power devices and components such as LEDs, Buzzer, microcontroller, sensors, etc. At the output of LM7805 one more electrolytic capacitor of 470uF (C2) is used which is used as a coupling capacitor to minimize voltage fluctuations caused by driver circuits, and microcontroller. For power indication a red color LED is used in

series with 1.8K resistor (R1). For various indications such as system status, alert, etc. few LEDs (SIG, FIRE, SMOKE) along with 470 Ohm series resistors (R5, R6, R7) are used. These LED and resistor pairs are connected to three GPIOs of microcontroller (U1-ATmega8A) to PD2, PD3, PD4 which controls these connected status LEDs. For beep/sound indication, a buzzer is used which is directly driven via one of the GPIO (PD5) of microcontroller. Apart from power supply and indication units this system is also having fire/heat detection sub-system which consists of two BJT (Bipolar Junction Transistors) as BC547 (Q1) & BC557 (Q2). These BJTs are configured in CE (Common Emitter) & CC (Common Collector) configurations with some resistor biasing (R11, R12, R13, R18). For better signal conditioning and amplification these two BJTs are arranged in darling-ton pair configuration. The first NPN BJT BC547 is acts as a primary stage/pre-amp whose signal is feed into second PNP BJT BC557 which acts as a output stage amplifier whose output is feed into one of the analog input GPIO of microcontroller. At the input stage (BC547) a reversed biased PN-Junction Diode (1N4007) is attached which acts as a heat/fire sensor. For sensors such as NTC thermistors, & LDR the analog input ADC GPIOs of microcontroller are utilized. These sensors are directly pulled-up to 5v and connected to microcontroller with some pull-down resistors of 10K (R3, R4, R8, R9, R10) which acts as a voltage division resistor network. To drive DC water pump and fan motor a MOSFET (Metal Oxide Semiconductor Field Effect Transistor) based driver circuit is designed which consists of two N-Channel MOSFETS P55NF06 (Q3, Q4). These MOSFETs are used in common drain configuration. To prevent MOSFETs from auto-switching due to leakage voltage into gate, two 100K pull-down resistors (R16, R17) are used. The motors are connected to MOSFET's drain with respect to 5v vcc. As motors are electromagnetic devices, they generate high voltage back/reverse EMF which can damage our MOSFET or low voltage electronics. So, to overcome this problem, two flyback/freewheeling protection diodes (D5, D6) are used. To minimize motor noise and to extend motor's life, two ceramic capacitors of 0.1uF (C3, C4) are connected in parallel with motors. These MOSFET's gates are controlled with two of the GPIOs of microcontroller which are configured as a digital output to source current.

Most of the process and I/O devices are controlled and driven using on board 8-Bit AVR microcontroller ATmega8A which is programmed to configure various GPIOs as outputs or inputs, various peripherals such as UART, timers, ADC, etc., monitor various sensors and control output devices as per the flow of system. For microcontroller programming a Microchip Atmel Studio 7.0 IDE (Integrated Development Environment) is used and Embedded C++ programming language is used. For hardware designing a Proteus 8.0 Professional software is used. In order to upload binaries to microcontroller a USB programmer along with ProgISP software tool is used, and for testing and debugging purpose, a serial monitor and digital logic analyzer is used.

4 conclusion

Thus "Smoke and Fire detection system using Heatmap Analysis" has been successfully developed that can be easily controlled form some distance. It has the ability to detect the fire through the smoke sensor

The application of introduced smoke and fire detection system is used in places such as school, colleges, offices, hospitals, industries, etc.It can also be used in space shuttles, airplanes, trains as a security system in case of fire emergency.

As a conclusion, the project entitled "Smoke and Fire detection Using Heatmap Analysis" has achieved its aim and objective successfully. In addition to advancement, With little modifications this system can also

be used in industries for automation tasks where the temperature, smoke, heat have to be monitored & maintained with the help of PID controllers. In electric vehicles , or in autonomous self-driving cars this system can be used to monitor temperature of battery and also provide some safety system in case of emergency. This system can also be used to monitor and track heat body with the help of multiple sensors within one area/room.

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