DESIGNING MICROCONTROLLER BASED ACCIDENTAL FIRE PROTECTION SYSTEM FOR SUGAR CANE PLANTATIONS

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INTRODUCTION

Sugar cane burning by accidental fire is a main cause of undetermined sugar loss in the sugar cane industry [1]. When sugarcane burns damaged cane stalks infect the bacteria (*Leuconostoc mesenteroides/dextranicum*), which then turn the sucrose contained in the plant into acid and produces dextran. The presence of dextrans during evaporation provokes an increase of scale deposits in the heating surface and hence a greater energy loss [2]. Large quantities of cane dry leaves can turn into a big fire in a matter of seconds. The heat generated here destroys all living plants and organisms that contribute to the decomposition of the soil surface. The remaining plant cells also become inanimate due to overheating of the water, so the plants do not show any growth later. Sugar cane burning also may be a risk to the humans who work in sugar cane fields [3].

A fire alarm system is a number of devices working together to detect and warn people through visual and audio appliances when smoke, fire or carbon monoxide is present [4]. Most existing forest fire detection systems rely on satellite imagery [5]. A weakness in this technology is that when there is bad weather or it is cloudy, then the satellite system cannot penetrate [6]. Different sensors can be used for connecting devices and collecting data. It reduces man-hour and helps to handle and interact with the data collected [7].

At present accidental fires are controlled by the fire brigade (Fire control unit) of the Lanka Sugar Company (Private) Limited. Fire detection method is, if the fire is present in the sugarcane field, persons who are in duties in fields inform the fire unit. Fire identification, informing the fire unit and response time of the fire unit to control the fire is too high. Because of that reason, the field was already damaged to a notable level when the fire unit reached the field.

The proposed solution to the above problem is to, design two systems for fire detection with fire prevention protocol and a notification system to notify the fire brigade.The fire detection system is installed in the sugarcane field and the fire notification system is installed in the fire brigade office.

METHODOLOGY

This project, is based-on Arduino Mega 2560 board and Arduino Leonardo board as the main controllers that interacts with SIM800L & SIM900A GSM modules which works in the communication part. This system has two separate systems which are Field System and Fire Control Unit's System. The Field system is installed in the Sugarcane field, and it includes Fire detection protocol and Fire prevention protocol. Fire Control Unit's system installed in the fire brigade office. These two Systems communicate via GSM Network. The microcontroller inside the Arduino board is used as the brain of these systems where they execute all the decisions as well as control the circuit flow.

Field system (Figure 01) contains Passive InfraRed Sensors (PIR), Infrared (IR) sensors and MQ02, MQ135 gas sensors, Arduino Mega 2560, SIM800L GSM module, 12V Digital input card, Relay for water pump and 12v Switched-Mode Power Supply (SMPS) and fuse panel.

Sensors are attached in the portable metal poles. Each pole contains one MQ02 and one MQ135 gas sensors, six IR sensors and four PIR sensors. (Figure 03). These poles are installed in the field at 14-20m distance (d) (Figure 04) at each pole. Microcontroller receive/input these sensor output data. Then the microcontroller identifies the fire and sends a message of fire alert and location of the fire, to the fire control unit's system via the GSM network. And the microcontroller turns on the water pumps. Water pumps spray water to the field by sprinklers. Pumps use water from already installed water tanks of the field to prevent spread fire to other sugarcane fields until the fire control unit reaches the field to control fire using high pressure water by the fire trucks. Field System powered by Solar panels or Main power grid.

The fire control unit's system (Figure 02) has a microcontroller, field indicators, fire alarm, LCD display and GSM module. Microcontroller receives the fire alert via the GSM module. Then the microcontroller turns on the relevant indicator bulb of the field and turns on the Fire Alarm. LCD display show the GPS coordinate of the relevant field. All field GPS coordinates are stored in the microcontroller and relevant coordinate display according to the field unit's alert.

After this procedure the fire unit can identify an accidental fire on the Sugar Cane field and its exact location to respond quickly to control the fire. Also, the drone team can follow the GPS coordinate to fly drones and get live video feedback of the burning field.

Sensors which were used in this project were 5v Sensors. Then the output voltage of the sensors was 5v. When installing sensors in the field, the 12v Input Card was designed to prevent voltage drop with the length of signal wires.

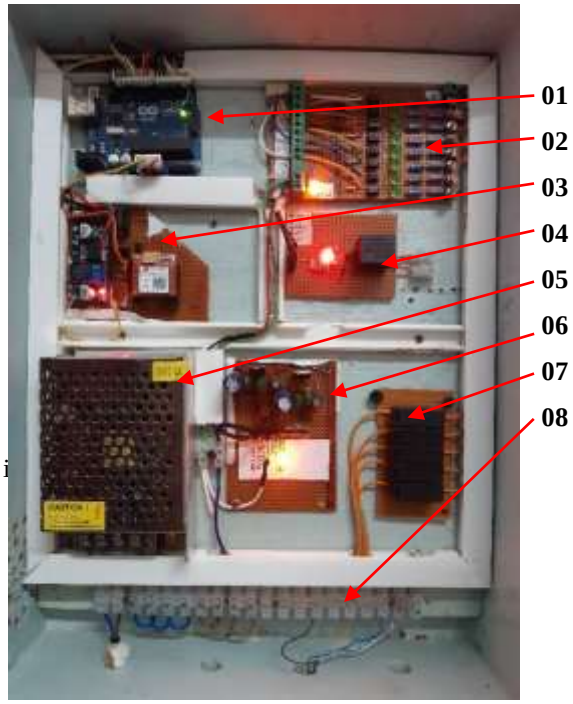


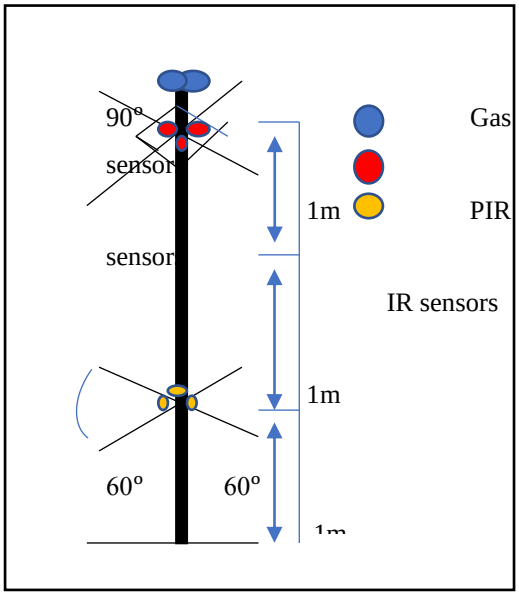
Figure 01: Field system with Arduino uno

(**01**-Microcontroller, **02**-12V input card, **03**-GSM Module, **04**-Relay

05,06- Power supply, **07**- Fuse panel, **08**- Connectors for power and sensors)

Figure 02: Fire control unit's system

(**01**- LCD display, **02** Field



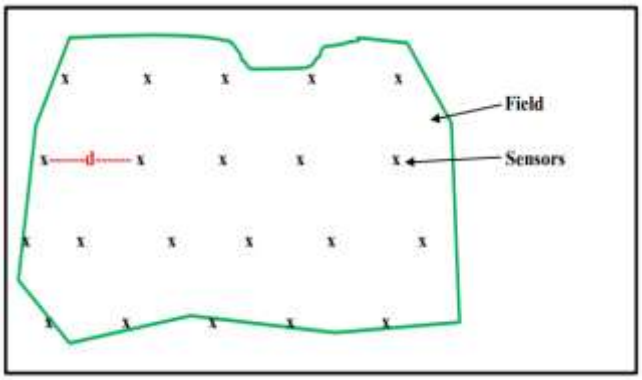
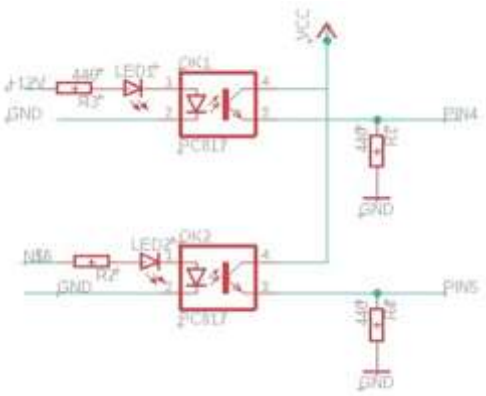


Figure 04: Sensor arrangement in the field

Figure 03: Sensors attached in metal pole

Sensors attached in the 3m tall portable metal poles. Portability is useful for removing sensors from fields at agricultural operations like harvesting and land preparation. Top of the pole, placed one MQ2 sensor and one MQ135 sensor. The PIR sensors placed at 3m height to prevent triggers to human's body temperature from those who work in the field. PIR sensor's horizontal detection angle is about 110°[8] then 4 sensors can cover 360°. IR sensors placed at the 1m height because many dry leaves have 1m-1.5m height. IR sensor's detection angle is about 60°[9] then minimum 6 sensors required for cover 360°. PIR sensor's maximum detection range is 7m. Then most effective distance between two sensor poles is 14m.



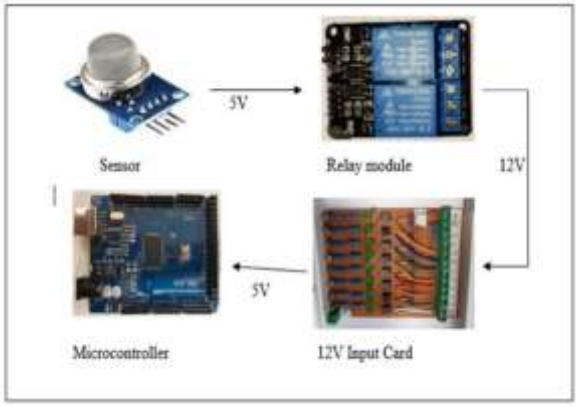


Figure 05: Circuit diagram of the 12V Input Card **Figure 06**: Voltage conversion process

Visual Studio code with Platform IO and Arduino IDE Version 8.1.13 used for programming Microcontroller. In this project use only all Sensors Digital output.

RESULTS AND DISCUSSION

- **MQ2 and MQ 135 sensors for smoke detection**

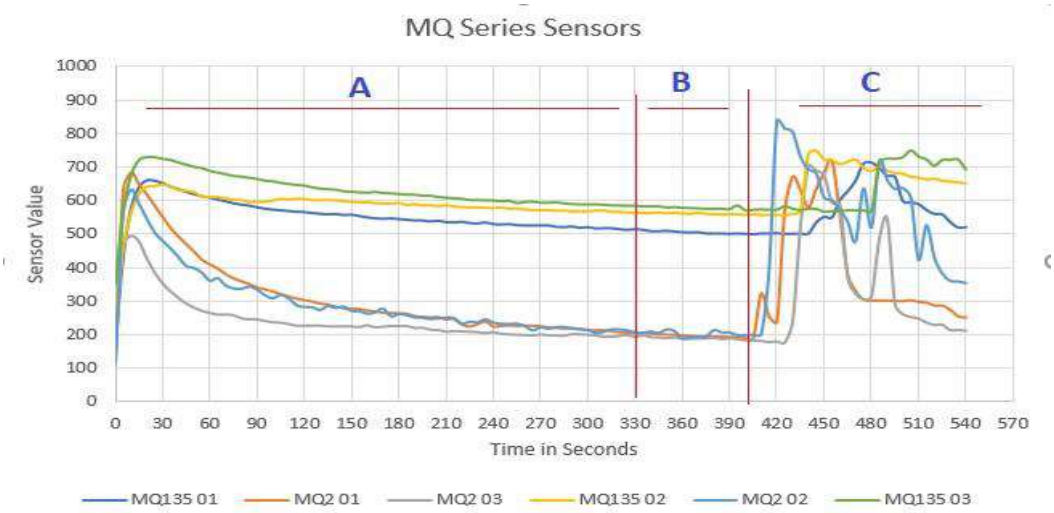


Figure 07: Sensor Values vs Time

This graph shows MQ2 and MQ135 sensors analog values with time. Area-A shows the heating stage of the MQ series gas detectors. 330s to 360s spent for heat up and stable the Sensors. This heating time was important for pause reading data, to prevent reading error high values from the microcontroller at the heating time. Area-B shows Sensor values in clean air. Area-C shows Sensor values at detection of smoke. According to the graph 250 value use as MQ2 Sensors Threshold value and 600 value use as for MQ135. MQ2 sensors detect smoke about at 200 – 10000 ppm, MQ135 sensors detect smoke about at 10- 1000ppm.

- **IR and PIR sensors for flame detection**

IR sensors have an on-board potentiometer to adjust sensitivity. Using these potentiometer sensors trigger point sets to trigger in 200lux flame intensity at 1m distance. PIR sensors adjusted to trigger at 7m in 200lux flame intensity.

- **Testing GSM modules for send and receive fire alert**

After the SIM800L module send the fire alert and SIM900A module receives the fire alert, the LCD display successfully shows the GPS coordinate of the burning field and turns on the area indicator of the relevant field.

Figure 08: LCD display shows GPS coordinate indicator

Figure 09: Turns on relevant area

CONCLUSIONS

This system has been designed to detect smoke and flame of the fire which is present in sugarcane fields and to notify the fire brigade. Based on the results infrared (IR) sensors successfully detect 200lux intensity flame at sensing range of 1m. PIR sensors successfully detect 200lux intensity flame and maximum sensing range is 7m. MQ2 sensors detect smoke about at 200 – 10000 ppm, MQ135 sensors detect smoke about at 10- 1000ppm. According to test results, the Arduino Mega 2560 microcontroller accurately runs the installed program and sends a fire alert to the Fire control unit system via SIM800L module. The prototype can identify Fire and notify the fire brigade and turn on water pumps in less than 20s.

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