Gas Leak Detector Using PIC16F877A Microcontroller on Board Ship.

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ABSTRACT

The liquified petroleum gas or LPG vessel and Liquified natural gas or LNG vessel mostly has a separate cargo pump room for operation of loading and discharging cargo. This place mostly has a tendency leakage of cargo that may endanger to person on board ship and environmental pollution. Some gas cargo there are more danger that other cargo if there have leaks because most of the gas are seamless and odorless and hard to identify if have a leakage in that place. The objective of these design project is to detect the presence of gas in surroundings if there have leakage on the system and will alert the operator or other crew by sound the alarm, blink the LED, and the description also will appear on LCD, so that the crew member will know the current situation and ready take for another action. This system is robust and cheap system because use of the microcontroller unit (MCU) system. The system is created using the Proteus 7.6 software and PIC C Compilers for simulate the design before it is be test on hardware model. The 10-bit microcontroller used for these systems. The sensor MQ-2 use for detecting gas leak like LPG, butane, methane, alcohol, propane, Hydrogen, and smoke.

KEY WORDS: *microcontroller unit, MQ-2 sensor, and liquified petroleum gas.*

NOMENCLATURE

LPG	Liquified petroleum gas
LNG	Liquified natural gas
MCU	Microcontroller unit
PIC	Peripheral Interface Controller
DC	Direct Current
ISGOTT	International Safety Guide of Oil Tankers and Terminals
SMS	Short Massage System
GSM	Global System for Mobile Communication
LCD	Liquid Crystal Display
LED	Light Emitting Diode
PDIP	Plastic Dual-In-Line Package
SnO2	Tin Oxide

1.0 INTRODUCTION

The Liquified petroleum gas or LPG carrier and liquified natural gas or LNG is one of the potentially hazardous cargo and expensive cargo transportation around the world's oceans. [1]LPG and LNG vessel normally have separate cargo pump room that recognized by International Safety Guide for Oil Tankers and Terminals (ISGOTT) [2]. Thus, the risk of leakage of cargo product is high and might be endanger to operator or crew member because the gas mostly colorless and odorless. By build the gas leak detector that can detect this kind of gas leaks, it can save the environment pollution and potential for explosion also can be prevent [3]. Specific method of control measures will improve the safety of the cargo operations.

1.1 Similar System

This System are taken from the research on the gas leak detector on LPG gas for small factory and house use. The gas detector sensor has multiple function and application use such as for safety, environmental prevention, instrumentation and health [4]. This system main objective is to give an advance warning if LPG gases are present that might be danger to personnel means there have a gas leaks to the surrounding.
Other similar paper shows a gas leaks detection with SMS warning.

This system is automatically detecting the presence of LPG by using a gas detector and with integration of Global System for Mobile Communications or GSM use to alert the personnel through sending an SMS to the specified mobile-phone [5].
Another similar study done on leaks sensing and evacuation system [6]. This evacuation system is neutralized the surrounding air by means of blower or fan. This system called smart system because capable to sense, analyses and actuated. The detector will give signal to solenoid valve to shut down the system if have any leaks on system then will trigger the alarm and together SMS will send to personnel through specified mobile-phone and this will alert the person if they are not present there.

1.2 Current System

Current system uses for safety of the operator in the cargo pump room is a fixed gas detection [2] system that capable of detecting the oxygen content in the pump room surrounding by continuously monitoring. The system sample points and sensor should be strategically placed. Sample points should be positioning within the exhaust fan to get the surrounding air sample. This system capable to detect the oxygen content but not to the other gases that may cause danger to operator in the pump room.

1.3 Proposed System

A simple system that can detect various type of gases in event of leaks to prevent the operator in danger situation. This design also robust, easy maintenance for ship crew, inexpensive, and effective.

2.0 METHODOLOGY

2.1 Component

This system component is consisting of (1) PIC microcontroller PIC16F877A [7]. This microcontroller unit is plastic dual in line package or PDIP and use Flash memory technology and it is possible to be write-erase many times. (2) MQ-2 gas sensor [6] is uses for detect the leakage gas presence. (3) liquid crystal display or LCD use for give a description and to tell the personnel what the sensor sense. (4) buzzer is used in the system to give alert to personnel in the room via audible sound. (5) Light Emitting Diode or LED use to give an alert to the personnel in case the system detects the hazardous gas containing in the room. Figure 1 illustrate the block diagram of the system component use and Figure 2, illustrate the schematic diagram of the whole system.

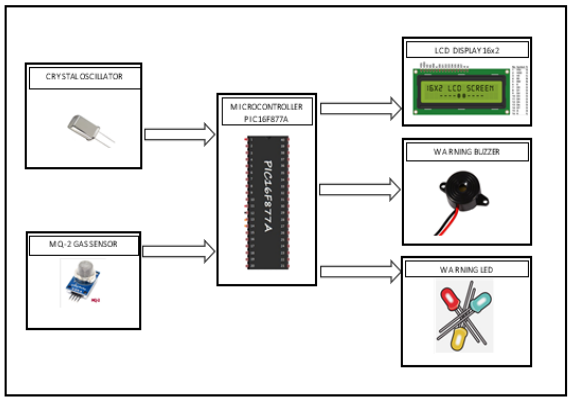

Figure 1: Block Diagram of the System component

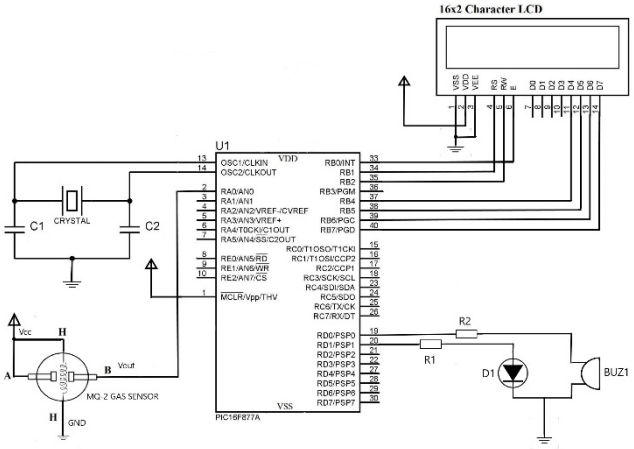

Figure 2: Schematic Diagram of the System

2.2 Operations

The system operation is explained as below:

When the gas sensor MQ-2 senses the atmospheric air or normal condition of air level in the pump room, the microcontroller will process this information then send signal to the LCD, the LCD will show gas not detected. Then, LED and buzzer also will not be activated.

When the gas sensor MQ-2 sense the presence of gas, the gas concentration or PPM will deflect from resistance ratio of the sensor sense. Through this, it will differentiate the type of gas. The MCU will process this information then the signal will send to the LCD buzzer and LED. The buzzer and LED will be activated to alert the crew. The LCD will display 'gas detected'.

The table 1 show the logic operation table of the system.

Table 1: Truth Table

INPUT				OUTPUT		
Methane	Butane	LPG	Smoke	LED	Buzzer	LCD
0	0	0	0	0	0	"Not Detected"
1	0	0	0	1	1	"Detected"
0	1	0	0	1	1	"Detected"
0	0	1	0	1	1	"Detected"
0	0	0	1	1	1	"Detected"

2.3 Microcontroller

PIC16F77A (Figure 3), are used for this system as a main component and act like the brain if the system that have 40 pin input and output. This MCU able to programmed and reprogram if system want to change. This MCU possible to keep some of the info memory permanently like code of transmitter, receiver frequencies and other data related. Figure 3 show the pin arrangement of this MCU.

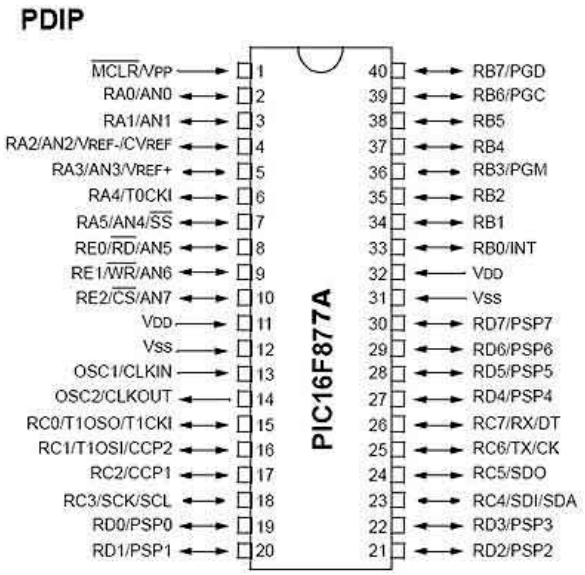

Figure 3: PIC16F877A microcontroller pin arrangement.

2.4 MQ-2 Sensor

The gas leakage is detected using MQ-2 semiconductor gas sensor. This sensor is powered by a 5Volt DC supply. MQ-2 gas sensor is made of Tin Dioxide or (SnO_2) [9]. This sensor can detect LPG, Butane, Methane, Alcohol, Propane, Hydrogen, and Smoke [8]. This sensor can sense the different gas through the different resistance ratio.

At normal condition, the conductivity of SnO2 is low [6], when the atmosphere is free from contamination of gas. When the target gas concentration such as methane appear in the atmosphere, the conductivity of SnO_2 increases, and this changes the sensor's resistance. The gases concentration (ppm) is calculated based of the equation (3). R_s is the change in resistance when the sensing mechanism detects gas, can be calculated as per equation (1), and *Ro* is the stable sensor resistance in fresh air or no gas presence, can use the equation (2). Using Ohm's law and the sensor schematic, *Vc* is the voltage current. *Vout* is the output (measured analog/digital value), and *Rl* is the resistance load.

$$R_S = \frac{(Vc-Rl)}{(Vout)}\text{-}Rl \qquad (1)$$

$$Ro = \frac{Rs}{(Fresh\ air\ ratio\ from\ data\ sheet)} \qquad (2)$$

$$Resistance\ ratio = \frac{Rs}{Ro} \qquad (3)$$

Figure 4 illustrate the sensor connection and Table 2 show the pin definition.

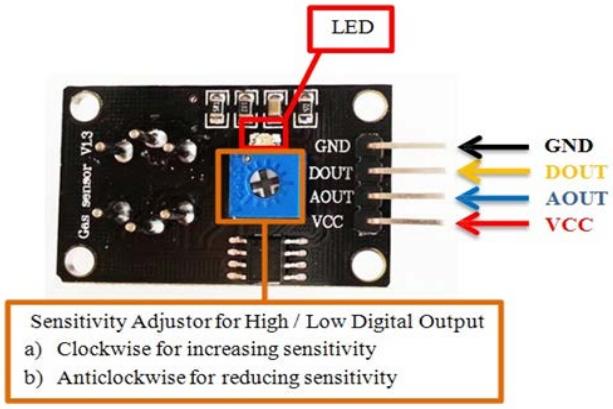

Figure 4: MQ-2 sensor pin arrangement

Table 2: Pin Definition

Pin	Description	Function
GND	Ground	Connect to Ground
DOUT	Digital Output	1. Output Signal: HIGH • No gas present • LED's Status: OFF 2. Output Signal: LOW • Gas present • LED's Status: ON
AOUT	Analog Output	The output voltage changing with the concentration of surrounding gas present. • Output voltage increases → increasing in concentration of surrounding gas. • Output voltage decreases → decreasing in concentration of surrounding gas.
VCC	+5V	Connect to +5V

2.5 Software

The "C compiler for the PIC Microcontroller," is use for compose, compile, process and programmed the codes use for the microcontroller into computer language. This compiler, which give authorize to the microcontroller are customized in high level of programming languages. The main basic capability of the entire system is to allow a timed settle with micro-seconds interval, to acknowledge the inputs, before delivered the signal to the output.

2.6 Programming Description

The program used to simulate the whole process is embedded in PIC16F877A microcontroller's C language. All the codes have been compiled and tested using CCS compilers**.**

2.7 System Flow

This system works in sensing of the presence of other gas in the surrounding air in the room by the gas concentration. The signal is sent to the MCU from analog to digital signal. The MCU then will decide on the next action, either triggering the buzzer and activating LED to alert the person in charge on the vessel to take further action while the LCD will display 'gas detected' if gas has been detected and will display 'no gas detected' in the normal room condition. Figure 5, illustrated the flowchart of the whole system.

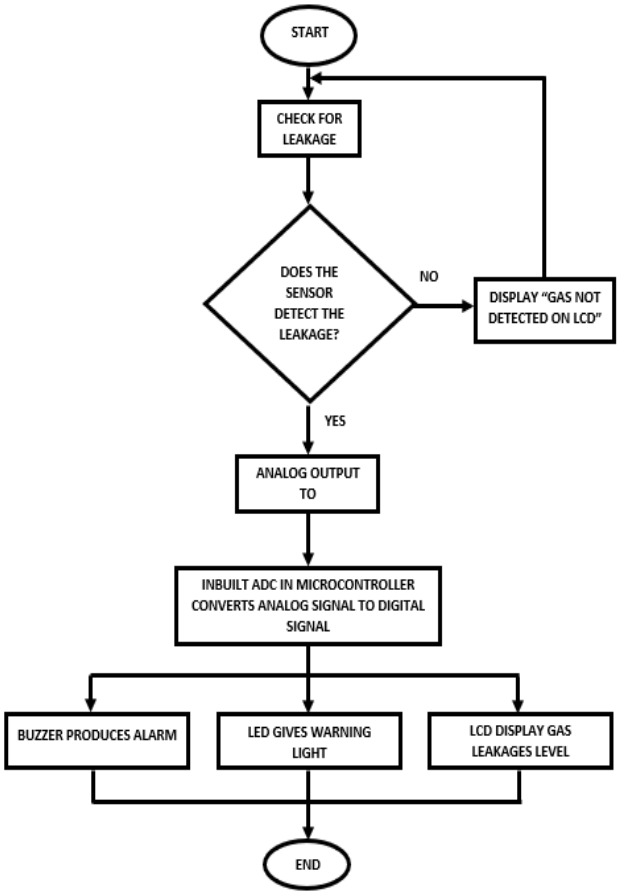

Figure 5: process flowchart of the system.

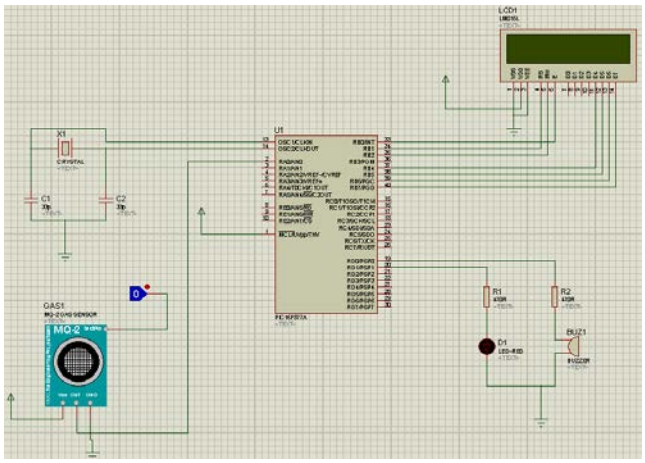

Figure 6: Input and Output Circuit Diagram

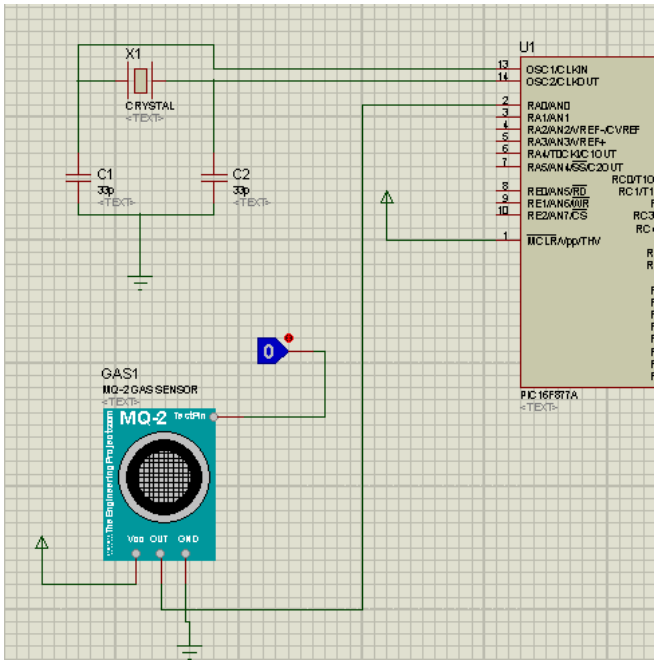

Figure 7: Sensor Connection to MCU

3.0 CIRCUIT DESIGN SIMULATION

The circuit was built in the software Proteus v7.6. The component that being use is chosen from the software library and some is downloaded to software like the gas sensor MQ-2, and the component connections were done by lines to the provided terminals. Then, program was later compiled using CCS C compiler. The output after compiler to hex file is loaded into PIC microcontroller. Finally, the simulation is tested for all the criteria conditions. The circuit used for simulation is given in Figure 6. The component connection to the microcontroller use 3 ports, A, B and D. The output from the sensors MQ-2 were connected to pin RA0 by using port A of the microcontroller as illustrate in the figure 7, while the output to the LCD is connected through pin RB0 till RB7 except RB3 in port B at MCU as shown in figure 8 below. Finally, another output to LED and Buzzer is connected to pin RD0 and RD1 via port D on MCU. Figure 8 illustrate the output connection of the MCU to the LCD, LED and buzzer.

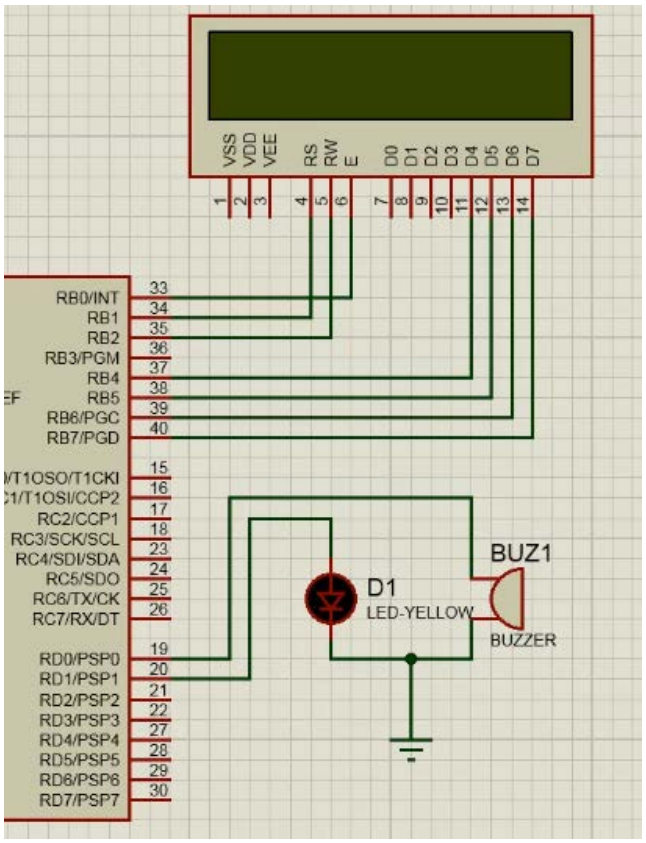

Figure 8: Output Connection from MCU

4.0 RECOMMENDATION

In this paper, the author shows the operation of gas leaks detection system. Other than that, the intelligence of the PIC16F877A MCU avail the input and output signal for the gas leak detection to sense certain kinds of gases. Through this design, the gas sensor can be replaceable if want to use to sense on other type of gases. From the design circuit, only few parts for alert signal are used. This system also can be insert with an interlock system for the cargo pump or isolation valve if have any gas leakage detection. In addition, this MCU could be reprogrammed to suit with another system if there have any changes to be made.

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6.0 CONCLUSION

In conclusion, this proposed system will ensure the safety crew on board and environmental issue by early detecting of gas leakage, so that the crew can do immediate action to minimizing or eliminate from accident happen. In future, this system might be focus on shut down the operation if have leakage detect and by mean time, the exhaust fan and blower will run to neutralized the surrounding of the pump room until the sensor detect clean air.

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