Microcontroller (MCU) on LNG Tanker Air lock System

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ABSTRACT

Ship carrying bulk liquefied gases are considered one of the most dangerous cargo carrying ships because of the hazardous and flammable properties cargo. In such, ships highest safety standards are maintained to avoid any kind of accidents from taken place, explosions being the most common of them. One such safety feature that is provided in gas carrier ships is air lock, a simple yet effective feature.

The aim of these papers is to describe a simple design on air lock system with the application of the microcontroller unit (MCU) based system. This design was simulated using the Proteus software and compiled using C compiler to simulate real air lock system on board using MCU.

The program has then compiled in PIC C Compilers, and were programmed into the microcontroller using a programmer for PIC 8-bit microcontrollers. This paper will offer the developments of the ship air lock system that will alert the crew in charged through signals. The model functioned suitably by using simulator software.
The air lock room is a gas tight space with two doors spaced minimum 1.5 m and maximum 2.5 m. I t is made up of steel. Doors of Air locks must have self-closing and no-holding back attachments.

Space must be mechanically ventilated and maintained at pressure higher than that of the surrounding space. Audio and visual alarm to be provided if both doors are opened simultaneously.

KEY WORDS: *PIC microcontroller, Air lock system, MCU*

NOMENCLATURE

CPU	*Central Processing Unit*
DO	*DOOR OPEN*
DC	*DOOR CLOSE*
LED	*Light Emitting Diode*
MCU	*Microcontrollers*
PIC	*Peripheral Interface Controller*

1.0 INTRODUCTION

An airlock is a device which permits the passage of people and objects between a pressure vessel and its surroundings while minimizing the change of pressure in the vessel and loss of air from it. The lock consists of a small chamber with two airtight doors in series which do not open simultaneously.

In gas carrier Air Lock is a protected space or room between dangerous gas areas/zones and weather deck. It is a type of gas safe space**.** Perfect example of such place is the protected entrance space of the cargo compressor motor room, which can be isolated from rest of the spaces which will be our main topic in this project.

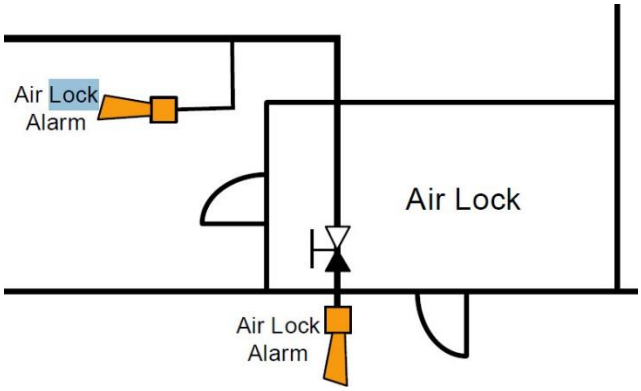

Figure 1: Layout of Air Lock Alarm System currently onboard

1.1 Current System

Current Air lock system operation onboard : (1) incorporates a control wiring circuit (2) for air lock alarm system which is controlled by relays, timers, switches, fuses, limit switches for door indications, differential pressure switches and many more of electrical components and wiring.

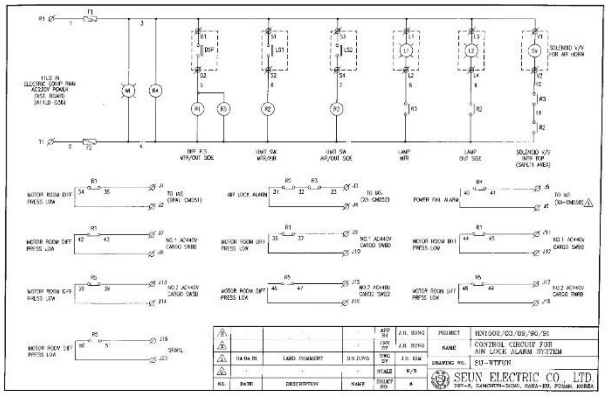

Figure 2: Control Circuit for Air Lock Alarm System currently onboard

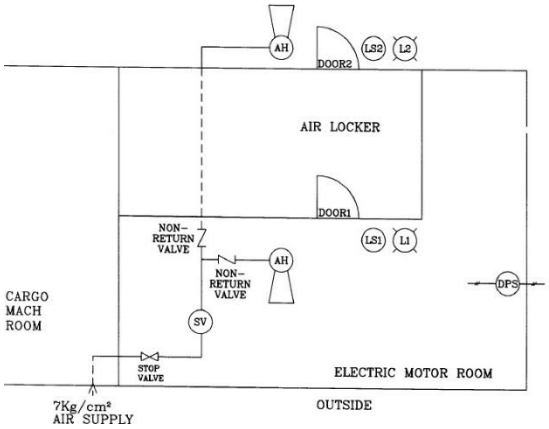

Figure 3 : Layout of Control Circuit for Air Lock Alarm System

1.2 Proposed System

A simple, easy, cheap, safer with lower voltage electronic control system (4) mostly suitable for hazardous flammable zones is highly proposed as to replace existing air lock systems onboard.

2.0 METHODOLOGY

A Microcontroller will constantly observe the indoor and outdoor of compressor room compartments. The limit switches will be attached to both doors to complete or break the circuit of the microcontroller. Based on the signals from the limit switches the MCU will then decide on the next course of action.

The MCU will trigger high signal once both doors open to its attachments to indicate that doors are open simultaneously. The high signal will cause a relay in safe location to activate an electrical driven motor horn or (air motor), alarm lamp and buzzer.

The LED will be illuminated at DCS panel and bridge to give warning signals for watch keepers. Alarm signal will also be sent to DCS to alert watch keeper of such breach of air lock system sequence.

2.1 Component

The components of the system consist of (4) PIC16F84A, light emitting diodes (LEDs) to turn as visual response, Buzzer which function as the hearing response aids at DCS or bridge, and limit switches that is installed to the indoor and outdoor connected with low voltage supplied to microcontroller. Motor that will be activated when needed, Relay which will be used to control the Motor and the Buzzer. Figure 4 illustrates the schematic diagram of the system design.

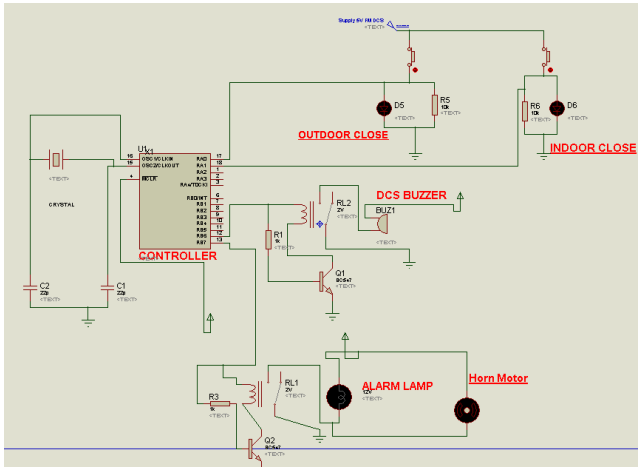

Figure 4: Simplified Schematic diagram

2.2 Operations

The operation concept is described below:

- When outdoor open to enter the air lock compartment the LED light of outdoor (close indication) at DCS will be off.
- When outdoor close, the LED light of outdoor close indication illuminates again.
- When indoor open to enter the compressor house the LED light of indoor (close indication) at DCS will be off.
- When indoor close, the LED light of indoor close indication illuminates again.
- If in case both doors open simultaneously, the MCU will trigger high signal to activate buzzer and relay which will activate siren motor and alarm lamp. Both doors (close indication) will be off.

Table 1, shows the logic of the operations.

Table 1: Truth Table

Input Ports		Output Ports						
Door No.1	Door No.2	Alarm lamp	DCS Input	Buzzer	Horn	Buzzer	LED Door CLOSE NO.1	LED Door CLOSE NO.2
1 close	1 close	OFF	OFF	OFF	OFF	OFF	ON	ON
0	1	OFF	OFF	OFF	OFF	OFF	OFF	ON
1	0	OFF	OFF	OFF	OFF	OFF	ON	OFF
0 open	0 open	ON	ON	ON	ON	ON	OFF	OFF

For input 0 indicates door open, 1 door close

2.3 Microcontrollers

PIC16F84A (Figure 5), is used for this system. This MCU is used as the brain of the system, it has the ability to function without other sophisticated modules to be attached. PIC is a family of reduced instruction set computing (RISC) microcontrollers manufactured by the Microchip Technology which is resultant from the PIC1650 that is formerly developed by General Instrument's Microelectronics Division. PIC is the integrated circuit which was frequently used to develop in controlling exterior devices and lightening the load from the main CPU in the system. Matched to a human being, the main CPU act as a brain and the PIC is same to our autonomic nervous system. Hence, it is recommended that 8-bit PIC16F84A microcontroller which is sufficient enough to act as the central control of the system.

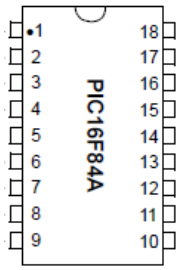

Figure 5: PIC16F84A Microcontroller Pin assignment (PDLP)

2.4 Software

The program used in our PIC MCU is C++ using C compiler for editing and compiling then simulate the program using Proteous schematic diagram.

The program is attached as bellow to empower the microcontroller to actuate the out ports based on input signals.

```
#include<16f84a.h>
#use delay(clock=4000000) //crystal 4mhz,

#define outdoor_open pin_A0
#define indoor_open pin_A1
#define siren_motor pin_B7
#define buzzer_DCS pin_B6
#define outdoor_indication pin_A2

void main()
{
// first bracket for program

output_low(siren_motor);
output_low(buzzer_DCS);
for (;;) // this open loops

  {
   if (input(outdoor_open)==0)
     {
      if (input(indoor_open)==0)
        {output_high(siren_motor);
         output_high(buzzer_DCS);
        }
      else
          {
          output_low(siren_motor);
          output_low(buzzer_DCS);
          }
      }

     else
     {
      output_low(siren_motor);
      output_low(buzzer_DCS);
      delay_ms(1000);
     }
   }
}
```

2.5 Programming Description

The program used to regulate the entire process is embedded in PIC16F84A microcontroller's C language. All the codes have been compiled and tested using CCS compilers.

2.6 System Flow

This system works in sensing doors switches which are attached to indoor and outdoor and send the signal to the Microcontroller Unit.

The MCU then will intelligently decide on the next course of action based on doors input when both doors open the MCU will activate the motor, siren, alarm lamp and buzzer.

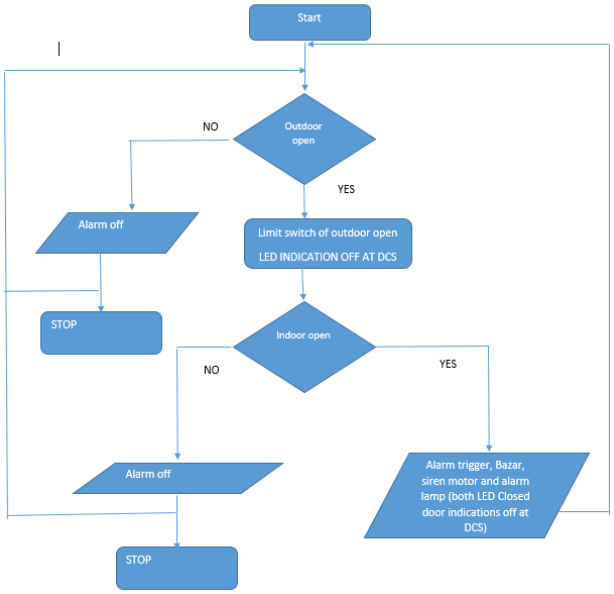

Figure 6: Flowchart of the system

2.7 Circuit

The circuit consist of microcontroller, power source of 5V supplied from DCS, input parts which comprises of limit switches and (8) LED indication, output system parts consist of alarm horn motor (7) or air horn motor, alarm lamp, DCS and bridge buzzer.

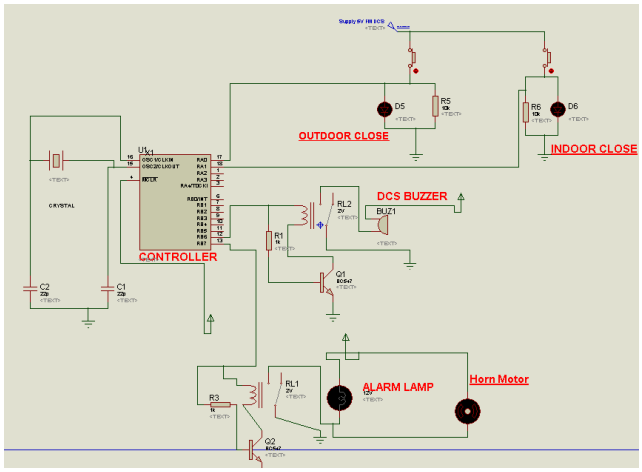

Figure 7: Input & Outputs

As in figure 7, all the 2 input sensors are connected using the Port A, (8) display is used with supply circuit connected with port A, and all the output of the system are connected using the Port B.

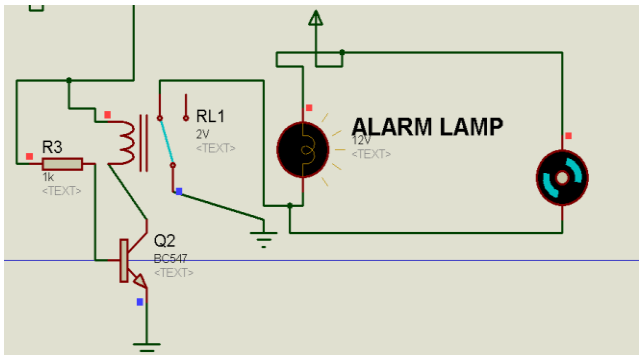

Figure 7: Alarm Circuit at Air lock space

Once both doors, indoor and outdoor are open, the alarm will automatically trigger by the MCU, to indicate an immediate attention by staff. MCU is connected to alarm through a relay as figure 7.

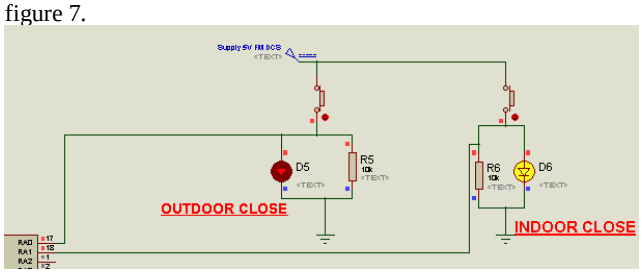

Figure 8: Both doors limit switch closed and LED indication on

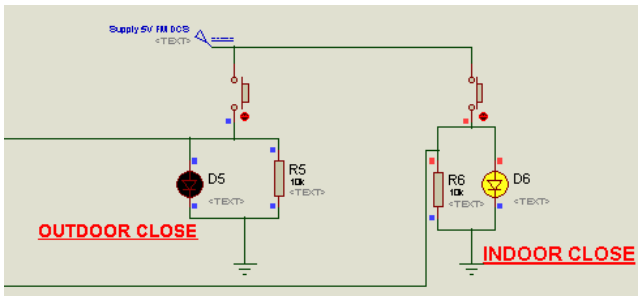

Figure 9: Outdoor limit switch open and LED indication off, and indoor limit switch closed and LED close indication on.

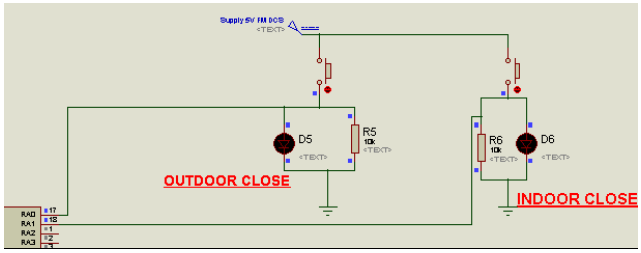

Figure 10: Both doors limit switches open, LED indication closed off.

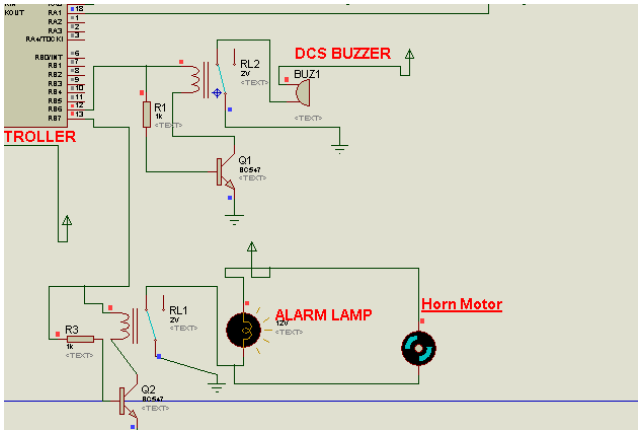

Figure 11: Alarm and buzzer relay on activating Alarm lamp, Horn motor and DCS buzzer.

3.0 CIRCUIT DESIGN SIMULATION

The circuit was then replicated in the software Proteus v7.6. In this software, the entire components of the circuit which is essential were carefully chosen from the software library and the connections were done by lines. The program was later compiled using CCS C compiler. The output, hex file of the program is loaded into PIC microcontroller using the PicKit2. Finally, the simulation is tested for all the conditions. The circuit used for simulation is given in Figure. 4. The connection to the microcontroller separated into 3 parts of circuits. The inputs from the sensors were connected to RA0 and RA2 pins (using Port A) of the microcontroller while the outputs of the system were

connected RB6 and RB7 for alarm relay to activate alarm horn motor, buzzer, and alarm lamp.

4.0 RECOMMENDATIONS

In this journal, the air lock monitoring system is presented using a microcontroller. This circuit is checked and controlled the integrity of the air locked space with only few additional equipment like buzzer, horn and LEDS used. Furthermore, the MCU could be reprogrammed to suit the regular regulation changes on board. Every one of these components are controlled and intelligently decided by the PIC16F84A - MCU and more application cases could be further explored.

5.0 CONCLUSIONS

Thus, this proposed monitoring system will ensure the occupational safety on board by minimizing the needs for regular rounds and check to be done on the air lock space. As well as ensuring safety of equipment's and ship in general.
This system could further be improved in near future as it is possible to reprogram the MCU add or delete any functions whenever required. Upcoming system could be focused improving the doors control, for example operating doors remotely or alerted wirelessly through a wireless module connected to the MCU.

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References

Co, S. E., & Ltd. (2005). *AIR LOCK ALARM SYSTEM FINAL.* Korea: (SATU CLASS LNG SHIP).

KaranC. (2019, November 29). *marineinsight.com*. Retrieved February 7, 2020, from Marine Insight: https://www.marineinsight.com/maritime-law/what-is-an-air-lock-on-gas-carriers/

Ramesh Babu Amathalai. (2019, January 2). Practical/Lab sheets. *Electrical, Electronic and Control Engineering*. Kuala Sungai Baru, Melaka, Malaysia: ALAM.

Ramesh Babu Amathalai, S. Z. (2019). Design, Modelling and application of Microcontroller (MCU) on Marine Tanks. 5.