Design and Application of Microcontroller (MCU) On Sliding Watertight Doors Operated by Servo Motor

Mohd Tajuddin bin Ishak [1], Zulhusmi bin Othman Sabar [2],
Nazurah binti Ngadiman [3], Mohd Najib bin Mat Harun[4]

[1-4)] *ACSU41 Student in Malaysia Maritime Academy, Malaysia*
[1-4)] *Marine Engineer in respective Companies*

*Corresponding author: [1] incetajuddin69@gmail.com, [2] zulhusmi2601@yahoo.com, [3] nonoicute_179@yahoo.com ,
[4] najib.kmn@gmail.com

Paper History

Received:
Received in revised form:
Accepted:

ABSTRACT

Watertight doors are special type of doors found on the ships which prevent the ingress of water from one compartment to other during flooding or accident and therefore act as barrier. There is 3 classes of watertight door which is Class 3 is sliding powered watertight doors. Sliding watertight doors normally powered by electrical and mechanical. The main objective of this paper is to describe a simple design with effective system, and application of the microcontrollers unit (MCU) based system on Sliding watertight doors. These design using ARDUINO UNO R3 and were simulated using the software Proteus 8 Professional and then later to implement and test in the hardware models. The program has then compiled using CCS C compiler, the output, hex file of the program is loaded into PIC microcontroller using the ARDUINO UNO R3. Regardless this system program is to improvise and ensures the effectiveness operation of sliding watertight doors. Beside that is to ensure the operation of these sliding watertight doors meets requirement by SOLAS.

NOMENCLATURE

MCU	Microcontroller units
LED	Light Emitting Diode
CCS	Custom Computer Service
IDE	Integrated Development Environment
RISC	Reduced Instruction Set Computing
PIC	Peripheral Interface Controller
PWM	Pulse with Modulation
AVR	Advance Virtual RISC
USB	Universal Serial Bus

1.0 INTRODUCTION

Watertight doors are usually hydraulically or electrically, and either horizontally or vertically sliding opening and closing. The reason why swinging doors are not provided in watertight bulkheads is because it would be impossible to close a swinging in case of flooding. Due to this reason, all watertight doors designed with sliding opening. Control for opening and closing the doors should be provided either side of the door as well as on the central operating console at the bridge. Powered operating sliding door should be provided with local audible alarm distinct from any other alarm in that area with shall sound whenever the door is closed remotely before the door begin to move. The sound should be audible until the door is completely closed. Powered operated sliding watertight doors must capable to closing simultaneously not more than 60 seconds.

1.1 Similar System

This section refers to some researchers' work that is related to the powered operated watertight sliding door. Electrically, hydraulically or pneumatically operated watertight sliding door are designed to be remotely and automatically closed in short period of time with a force which is sufficient to overcome not only the weight of the door but also water flowing through opening and closing. Hydraulically operated consist either two independent power sources (motor and pump). In both cases there must also be hydraulic accumulator capable of providing stored power to operate the door. Electrically operated door must have an independent electrical system and motor for each door with the power source capable of being automatically supplied by transitional source of emergency power.

1.2 Current System

Nowadays, most of the operation of the watertight door are operated either hydraulically or electrically and even pneumatically. Operation will be locally or on control center (bridge). All the operation of watertight sliding door are same either power operated by hydraulic or electrical. Many companies which is designing and producing watertight door come with almost same design and control system. But, some design still not able to perform very well which still could lead some injury to operator and even damaged to system itself. Beside the construction and system of watertight door, it also importance for all ship crews especially engine room personal to familiar and will be able to operate the watertight doors in all situation either normal working condition or emergency situation. So, the watertight sliding doors must be easily operable.

1.3 Proposed System

A very simple control system which is easy to configure, easy to be operated, control system can be install direct and run with independent servo motor or as an extension system to operate the equipment, an installation of this control system may give beneficial assistant for the ship crews to operate, it will save more time, energy and cost.

2.0 METHODOLOGY

The control system basically working on sliding doors, hydraulic system may not reliable upon installation if it's fully operated by servo motor. The microcontroller basically operates on opening and closing of the sliding door, this controller fitted with 3 push button which is opening, closing and reset, the signal from push button will direct the servo motor to operate on fully close (signal 180 degree) and fully open (signal 0 degree), reset button to reset the system back to nominal condition (180 degree close). At maximum opening and closing (signal 0 - 180 degree), alarm and LED will be triggered.

2.1 Component

The components of the system consist of (1) Arduino UNO R3, is an open-source microcontroller, the board is equipped with sets of digital and analog input/output pins that may be interfaced to various expansion boards and other circuits. (2) Push button to activate the system by sending a signal to required components. (3) Servo motor working as component to drive the main equipment on demand. (4) Light emitting diodes (LEDs) to turn as visual response, (5) Buzzer which function as the hearing response aids. (6) Resistor are used to reduce current flow and also adjust signal levels.

Figure 1 illustrates the schematic diagram of the system design.

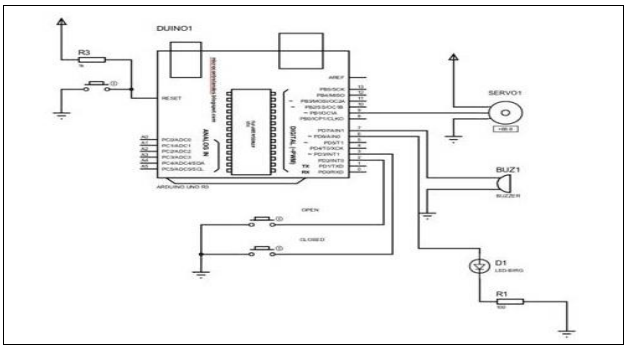


Figure 1: Simplified Schematic diagram

2.2 Operations

The operation concept is described below:

- When close button pushed, servo motor position travel from 0 – 180 degree which is from open to close position.
- At 180 degree, close position, buzzer and LED triggered and servo motor will stop turning.
- And when open button pushed, servo motor position travel from 180 – 0 degree which is from close to open position.
- At 0 degree, open position, buzzer and LED triggered and servo motor will stop turning.
  Reset button will reset the position of servo motor at Its original value, 180-degree close position

2.3 Microcontrollers

ARDUINO UNO R3 is used on this system. The MCU is used as the Central of the system.
The Arduino UNO is the most used and documented board in the Arduino family.
.
The Arduino UNO is based on ATmega 328p microcontroller and it also has ATmega16U microcontroller.

ATmega 328p: It is the brain of the Arduino and it is a high performance Atmel Pico power 8bit AVR RISC based microcontroller which is cable of executing powerful instruction in single clock cycle.
ATmega 16U2: This microcontroller takes care of the USB connection and ICSP bootloader.

The Arduino UNO has 14 Digital pins (6 PWM) and 6 Analog pins

DIGITAL PINS: Pin 0 to Pin 13
In which pin 0 and pin 1 are used to receive and transmit serial data. PWM: 3, 5,6,9,10,11

These 6 pins can be used as PWM (Pulse Width Modulation) pins. Using these pins it can control the voltage in turn, control the brightness of led, speed of the motor by varying the voltage.

ANALOG PINS: Pin A0 to Pin A5
The main function of Analog pins is reading the values from Analog sensors.

POWER SYSTEM/POWER PINS:
The Arduino UNO has super convenient power management and built-in voltage regulation.

The external power supply can be given by Connecting power source (7-12V DC) to DC power jack (or)
Connecting a battery lead to VIN and Gnd.

ATmega 328p has 32KB of flash memory to store your program and 2KB of SRAM and 1KB of EEPROM.

It has 16MHz clock on board makes it fast and speediest micro controller.

It has a reset button to reset the program on chip.
A Led on board is mapped to pin 13 for debugging and testing purpose.
A power Led to indicate power.
Two Led for RX and TX which blinks when the serial communication takes place.

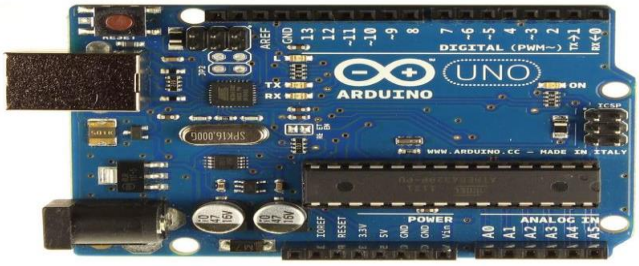


Figure 2: ARDUINO UNO R3 MCU

2.4 Software

The "C compiler for the MCU," is utilized for compiling the codes for the microcontroller. These compiler, which empowers the microcontroller to be customized in high level programming languages, together with PicKit2 programmer. The algorithm of the codes will decide the state of the parts by actuating the microcontrollers input - output ports taking into account the particular tasks. The fundamental capability of the entire system is to allow a timed with micro-seconds interim, to acknowledge the sensor inputs, and to activate the outputs with enacting the Alarm or the Motor.

The Arduino software used for structuring the programs in segments of to perform individual tasks. It has been used when one needs to perform the same action multiple times in a program. It is written in functions from C and C++. It is used to write and upload programs to Arduino compatible boards, but also, with the help of 3rd party cores, other vendor development boards.

The Arduino supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main () into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino employs the program CCS Compiler to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware.

2.5 Programming Description

The program used to regulate the entire process is embedded in ARDUINO UNO R3 microcontroller's C language. All the codes have been compiled and tested using CCS compilers.

Arduino Program used for composing, editing, and programming the codes for microcontroller.

2.6 System Flow

This system works when "Open" button pushed then the servo motor will be operate to open the door. It operated by giving signal to the Microcontroller Unit "ARDUINO". The MCU then will intelligently decide on the next action, by activating the Servo Motor and operated the sliding door. Once the sliding door fully open (180◦ position), the signal for activating the buzzer will send to triggered the buzzer and LED's light on (Figure 3).

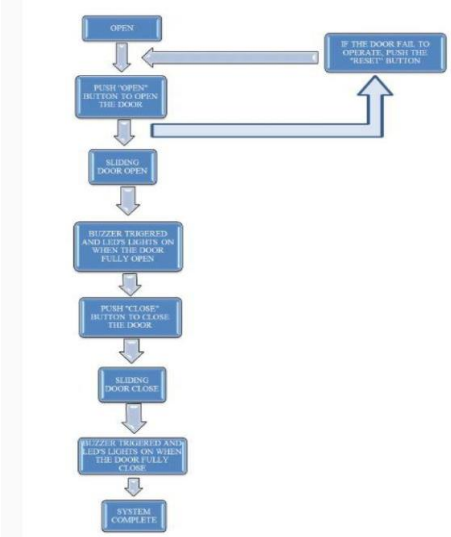


Figure 3: System Flowchart

2.7 Circuit

The circuit have four main component the power source section, microcontroller segment, which comprises the system input parts, and the output parts. All these modules are integrated to the Arduino unit.

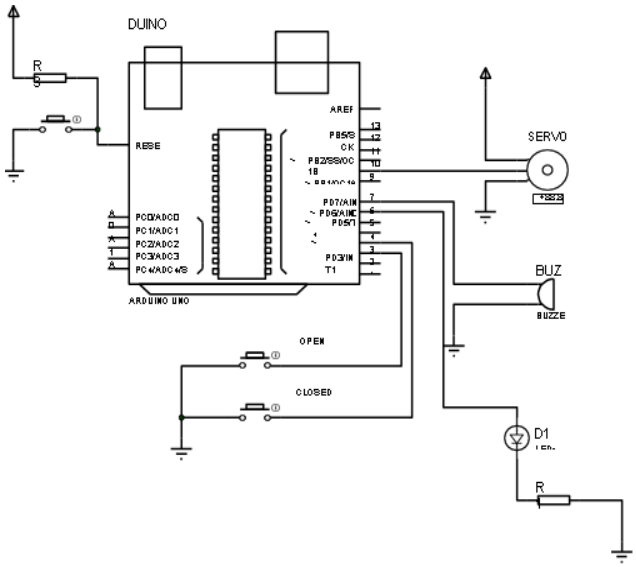


Figure 2 : Input & Outputs

As in figure 4, all the 3 input are connected using the Port RESET, Port D3 & Port D4 and all the output of the system are connected using the Port B1(servomotor), Port D6 (LED) & D7 (buzzer).

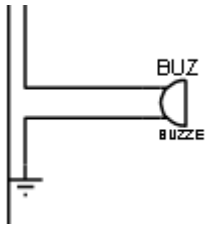
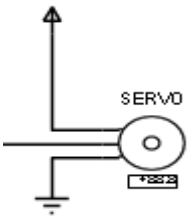


Figure 3 : Buzzer Circuit

Once the RESET or OPEN or CLOSE button pressed, the buzzer will automatically trigger by the ARDUINO, to indicate an immediate attention is needed by the crew of the vessel. The ARDUINO will be connected to the buzzer through as in figure 5.



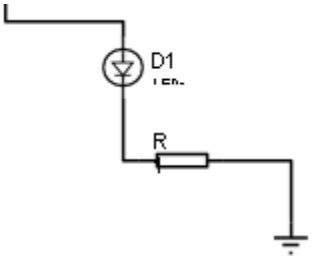


Figure 4 : Servomotor Circuit

The Servomotor, and LED will start automatically when the button pressed, and eventually stopped automatically when the servomotor reaches to the 0 degree or 180 degree (Figure 6).

3.0 CIRCUIT DESIGN SIMULATION

The circuit was then replicated in the software Proteus 8 Professional 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 ARDUINO UNO R3. 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 RESET, PD2 AND PD3 (using Port D) of the ARDUINO while the outputs of the system were connected PD6 through for the display units (LEDs), and PD7 is connected to the alarm (figure 5), and finally the PB1 is used to connect to the servomotor (figure 6).

4.0 RECOMMENDATIONS

In this paper, the author presented the operation of sliding door controller. Besides, it is demonstrated to utilize a ARDUINO UNO R3 as the part to a circuit for sliding door controls. This circuit checked and controlled the servomotor and utilized LED and buzzer for signals. From the equipment circuit, only few external peripherals are used. In addition, the ARDUINO could be reprogrammed to suit the regular regulation changes on board. Every one of these components are controlled and intelligently decided by the ARDUINO UNO R3 and more application cases could be further explored.

5.0 CONCLUSIONS

Thus, this proposed system will ensure the occupational safety on board and protection against flooding by minimizing the time for closing all normal watertight and weather tight doors for the crew.
This system could further be improved in near future. Upcoming system could be focused on enhancing the means of security by using password or fingerprint, visual aids, by integrating Liquid Crystal Display (LCD) to the system, allowing the crew to know exactly the position operation and even allowing the crews to be alerted wirelessly through a wireless module connected to the ARDUINO.

References

[1] R. B. Amathalai, "PROTEUS Program," in *Practical/Lab Sheets*, Alor Gajah, Akademi Laut Malaysia, 2019, pp. 1-48.

[2] S. Z. W. C. Ramesh Babu Amathalai, "Design, Modelling and Application of Microcontroller (MCU) on Marine Tanks".

[3] Z. Kundrat, "Smart Safety Door based on Arduino Uno R3," POLITEKNIK NEGRI BANDUNG, 2016. [Online]. Available: https://www.slideshare.net/ZiddanKundrat/smart-safety-door-based-on-arduino-uno-r3. [Accessed 1 MARCH 2020].

[4] KARTHIK_INNOVATOR, "INTRO TO ARDUINO UNO R3," Electronic Techwizard, [Online]. Available: https://www.instructables.com/id/INTRO-TO-ARDUINO-UNO-R3/. [Accessed 1 MARCH 2020].