Monitor and Operate Safety Devices on Marine Main Air Compressors Using Microcontrollers

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ABSTRACT

Main Air Compressors on merchant vessel are essential and critical machinery which produce compressed air for starting the Main Engine and Auxiliary Engines. [1] Apart from that, it also used as control air and service air onboard. Since Main Air Compressors is a vital machinery for a safe operation of a merchant vessel, they should be continuously monitored throughout it operation to prevent and any unforeseen damage and loss of compressed air. The purpose of this paper is to explain a proposed system to monitor the marine air compressors in a low cost system and application of the microcontrollers unit (MCU). This design is stimulated by Protues software. The program are compiled in PIC C Compilers, and programmed into microcontroller using a programmer for PIC 16-Bit microcontroller. This paper will show the enhancement of Marine Air Compressors monitoring system that will alert the duty watch keeper in charge of an engineering watch through audible and visual alarm. The priority of this system is to reduce and ease the task of the duty watchkeeper in monitoring Marine Main Air Compressors and ensure the safe operation of equipment.

KEY WORDS: *PIC C Compilers, Safety Devices, Marine Main Air Compressors, Microcontroller Unit (MCU)*

NOMENCLATURE

MCU	*Microcontroller Unit*
PIC	*Peripheral Interface Controller*
CCP	*Capture, Compare, Pulse- wide modulation*
USART	*Universal Synchronous and Asynchronous Receiver and Transmitter*
EPROM	*Erasable Programmable Read-Only Memory*
UMS	*Unmanned Machinery Spaces*
MAC	*Main Air Compressors*
DC	*Direct Current*
LCD	*Liquid Crystal Display*
LO LP	*Lubricating Oil Low Pressure*
LED	*Light Emitting Diode*
HIGH TEMP	*High Temperature*
EMER. STOP	*Emergency Stop*
AIR COMP.	*Air Compressor*
RISC	*Reduced Instruction Set Computing*
CPU	*Central Processing Unit*
LO	*Lubricating Oil*
ASAP	*As Soon As Possible*
FB	*Fan Blower*

1.0 INTRODUCTION

Factors to be considered for running the vessel with Unmanned Machinery Spaces (UMS.) The arrangements should ensure safety in all conditions, which should be equivalent to manning with manned machinery space. A comprehensive alarm system is to be provided, for indication of machinery faults. This system should be capable of displaying (by means of a panel of lights) any abnormality of the machinery, both on the Bridge, as well as in the Accommodation spaces, including the Duty Engineer's cabin and the chief Engineer's cabin, all public rooms.

1.1 SIMILAR SYSTEM

Safety devices on Marine Air Compressors typically should have some common safety cut-off systems but can be vary depending on makers designed cooling system. There are two most common cooling type of Marine Air Compressors which are:
i) Air Cooled Type Marine Air Compressors
ii) Water Cooled Type Marine Air Compressors.
If an Air Cooled Type Marine Air Compressors, some safety devices are not required such as Cooling Water Temperature High

Alarm, Cooling Water Pump Failure Alarm and etc. [1]

1.2 CURRENT SYSTEM

As for now on most onboard vessel the safety devices are been monitored via pressure transmitter and it will give signal to the circuit breaker to trip in order to stop the equipment so that there will be no any damage or prevention of accident and safety of the crew. [3] Although they are very reliable in design, they do have some setbacks. All pressure transmitters should be tested periodically to prevent any malfunction. For an example a mechanically monitoring pressure transmitter, the most common problem is the seizure of diaphragm or pressure spring. So it is very important to maintain a good engineering practice

1.3 PROPOSED SYSTEM

Our proposed system is very much required in the marine industry in respect of its reliability, accuracy, advanced monitoring system where installation cost for our system is very less and a very hassle free of maintenance and inspections.

2.0 METHODOLOGY

A Microcontroller unit (MCU) will be monitoring the safety operation set value during the operation of Marine Air Compressors. Any deviation in the set value will triggers an audio and visual alarm thru its respective ports on the MCU. Each LEDs which are fitted, represents an individual safety device. For certain alarm as per requirement the Marine Air Compressors must be shut off if set value reached. Whereas there are also some safety monitoring system which allows the Marine Air Compressors to continue in operation as they do not possess any treat to the equipment. Control and monitoring system are very reliable and make the task of the crew onboard ship much more easy and convenient.

2.1 COMPONENT

The components that are being installed in this system consists of two Microcontroller Units respectively (1) PIC16F87 and (2) PIC16F84A. Both of them are the core components which brains the monitoring and controlling the safe operation of the system. [4] .They are also known as Plastic Dual in Line Package. These MCU s are fitted with individual (3) crystals which function to protect the MCU s from being triggered with excessive electricity throughout its operation. (4) Five Light Emitting Diodes which presents separate safety cut off functions, (5) Buzzer is to provide a audible alarm, (6) Switches which functions as transmitter, (7) Motors as MAC, (8) Push Button is for the emergency stop in event of failure, (9) DC Fan is fitted for cooling purpose of the switch board, (10) Ammeters is fitted to monitor the current flow in the circuit line, (11) LCD Display is to indicate operation mode of the MAC.

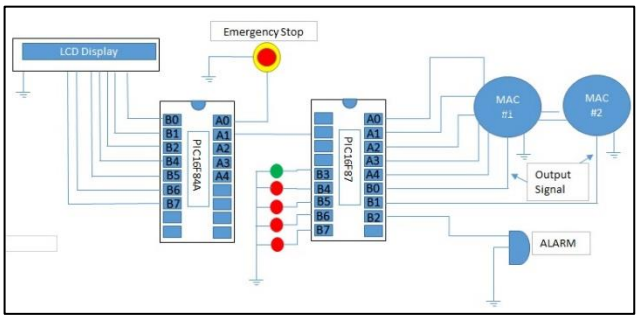

Figure 1: Simplified Schematic diagram

2.2 OPERATION

The operation concept is described below:

- When Emergency Stop pressed, all output ports disconnected from power source. The purpose of this switch is to isolate the power source to the compressor in event of abnormal operation or inspection and maintenance.
- When LO LP switch activated, LED LO LP will be light up, the Alarm trigger and the Compressor will be OFF. This indicate that failure in LO system of compressor.
- When OVERLOAD switch activated, LED OVERLOAD will be light up, the Alarm trigger. At the same time, the Compressor will be OFF. This condition occurs due to motor overloaded by faulty of compressor or electrical component. Need to be rectified before start the system back.
- When RUN switch is ON, LED RUN will be ON, there is no alarm will be trigger. One Compressor will run as per requirement. That mean compressor is running under normal condition.
- When the LONG RUN timer activated, the Alarm and LED LONG RUN will be ON. However, both Compressors will be run at the same time to fill up the air bottles. This indicate faulty in air compressor parts or leakage of compresses air pipe line and need to rectified the fault in no time.
- When the HIGH TEMP switch is activated, LED HIGH TEMP will be turn ON and continue with alarm activation. The compressor will be OFF. HIGH TEMP is activated due to poor cooling system and need to troubleshoot immediately to put the system back to normal

Table 1.0 and Table 1.1, shows the logic of the operations.

Table 1.0: Truth Table

Input Ports			Output Ports						
Emer. Stop A0	S1 A1	S2 A2	LO LP B0	Over Load B1	Run B2	Long Run B3	High Temp B4	Alarm B5	Air Comp. B6
1	0	0	OFF	OFF	OFF	OFF	OFF	OFF	OFF
0	1	0	ON	OFF	OFF	OFF	OFF	ON	OFF
0	0	1	OFF	ON	OFF	OFF	OFF	ON	OFF

Table 1.1: Truth Table

Input Ports			Output Ports						
S3 A0	S4 A1	S5 A2	LO LP B0	Over Load B1	Run B2	Long Run B3	High Temp B4	Alarm B5	Air Comp. B6
1	0	0	OFF	OFF	ON	OFF	OFF	OFF	ON
0	1	0	OFF	OFF	OFF	ON	OFF	ON	ON
0	0	1	OFF	OFF	OFF	OFF	ON	ON	OFF

2.3 MICROCONTROLLERS

PIC16F84A and PIC16F87 (Figure 2), 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 acts as a brain and the PIC is same to our autonomic nervous system. Although the function for the both MCU are same, the capacity of both are different. PIC16F84A (1024B code, 68B data, 64B EPROM, Ports A-B, 1xTimers). PIC16F87 (7168B code, 368B Data, 256B EPROM, Port A-B, 1xCCP, 3xTimers, USART).

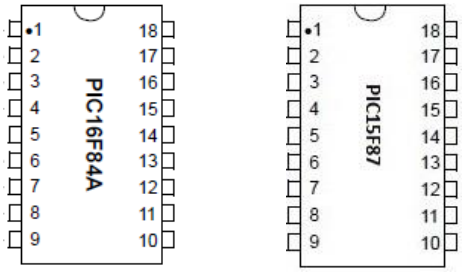

Figure 2 : PIC16F84A and PIC16F87 Microcontroller Pin assignment (PDLP)

2.4 SOFTWARE

The "C compiler for the PIC MCU," is utilized for composing, editing, compiling, and programming 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.

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 measure the air compressor's condition by safety devices which are fitted to air compressor and send the signal to the Microcontroller Unit. The MCU will intelligently decide on the following action, either cut-off or cut-in the Motor follow with trigger the Alarm to allow the person in charge on the vessel to take further action (Figure 3).

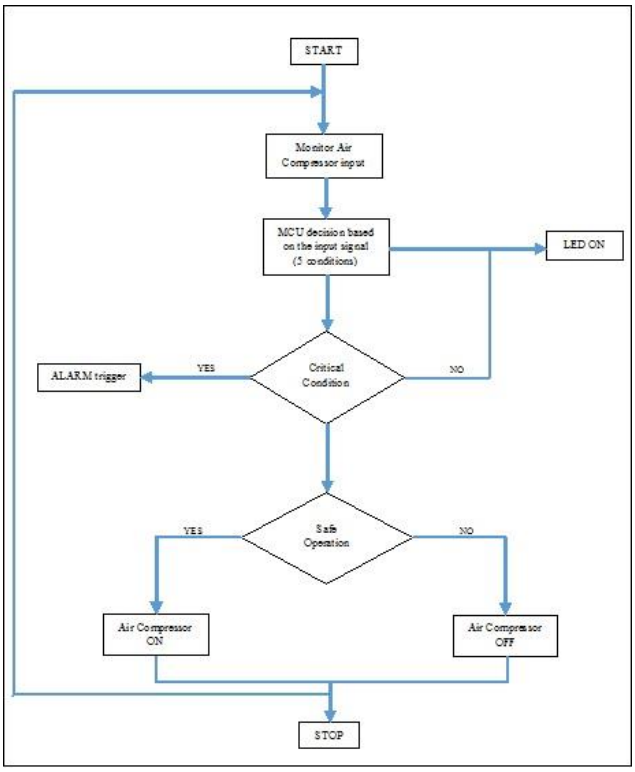

Figure 3: Flowchart of the system

2.7 CIRCUIT

The circuit build by the power source section, microcontroller segment with emergency stop and LCD display, microcontroller segment, which consist the system input parts, and the output parts. All these modules are integrated to the MCU unit.

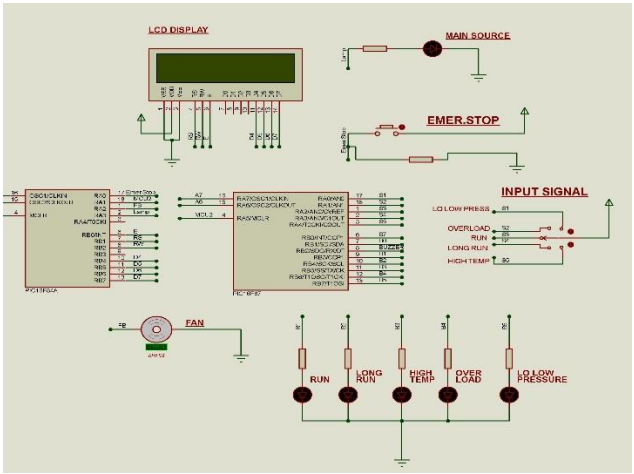

Figure 4: Inputs and Outputs

As in figure 4, all the 5 input sensors are connected using the Port A, and all the output of the system are connected using the Port B

including the display units (LEDs).

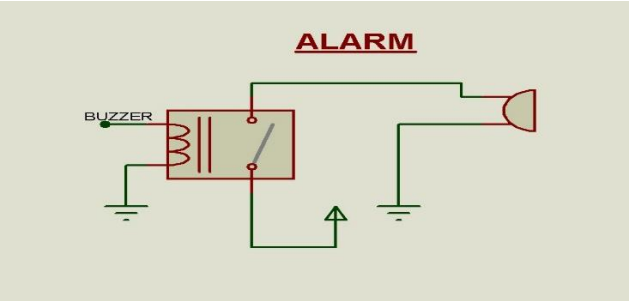

Figure 5: Alarm Circuit

In case of LO low pressure switch, high temperature switch, motor overload or compressor long run timer activated, the alarm will automatically trigger by the MCU, to indicate an immediate attention is needed by the crew of the engine room. The MCU will be connected to the Alarm through a relay as in figure 5.

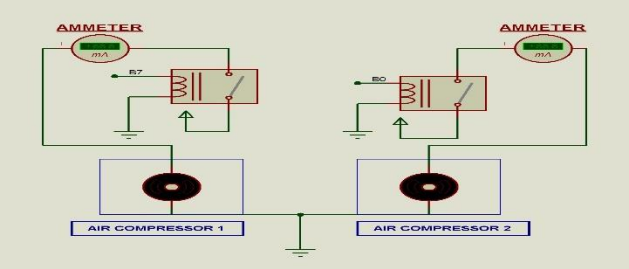

Figure 6: Main Air Compressors Circuit

The air compressor will stop immediately when pressure switch, temperature switch or motor overload due to high ampere to prevent major defect to air compressor. The air compressor will normal run as per requirement or continue run in case of long run timer activated and its need to be attend ASAP. (Figure 6).

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 MCU #1 (PIC16F87) separated into 4 parts of circuits. The inputs from the sensors were connected to RA0 till RA4 pins and RA5 is the input for MCU #2 (PIC16F84A) using Port A of the microcontroller while the outputs of the system were connected RB3 through RB7 for the display units (LEDs), both MAC connected respectively to RB0 and RB1, and Pin RB2 is for the buzzer. The connection for MCU#2 is also separated into 4 parts of circuits. The connection of Emergency Stop is connected to Pin A0, source power for MCU#2 is connected via Pin RA1, Fan Blower (FB) is connected to Pin RA2 and RA3 as source power lamp.

The output port (Port B) Pin RB0-RB7 are connected to LCD display.

4.0 RECOMMENDATIONS

Typical operation of Marine Main Air Compressors with safety devices is presented through this paper by the author. Briefly the effectiveness of using MCU for operation and monitoring is detailed by using digital inputs compare to analogue inputs. Due to a challenging environment, continuous working condition and age factors, the MCU are still can be reprogrammed to suit its performance.

5.0 CONCLUSIONS

There should not any compromise in the safety of crew onboard ship. Our proposed system, which uses the MCU to operate and monitor the MAC simplifies the task and able to ensure the safe operation of a ship is maintained at all time. The usage of MCU can be further applied to all machineries onboard as they are capable to be improvised to more advance features and applications.

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