The Intrinsic Controller Design for Multi Motor Drive System Using RISC Microcontroller

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Abstract: - In this paper the intrinsic principle of underground safety design was presented, in order to use a microcontroller for multi motor drive system. An explosive atmosphere is an environment where every mistake can cost material damage but the most important can cost loss of life. The most used methods for design, which assure all the exigencies for dangerous condition, is the intrinsic safety protection. This requires a small power consumed by equipment. Of course these need the necessary protections that are required in such working condition. Human decision factor can be replaced in many cases, eliminating the danger of some events caused by it. Microcontroller can be used in underground dangerous microclimate as part of command in these hazardous environments, because can provide a proper development activities.

Key-Words:- RISC microcontroller, hazardous area, safety barrier, algorithm, MATLAB-SIMULINK

1 Introduction

An intrinsic safety circuit is defined by the IEC 60079-11 standard at 3.1.4: as a "*circuit in which any spark or any thermal effect produced in the conditions specified in this standard, which include normal operation and specified fault conditions, is not capable of causing ignition of a given explosive gas atmosphere*".

Association between electricity and explosion phenomenology has been known to man since the early twentieth century. Specific prevention measures were regulated in this sense in different geographic locations, CENELEC - EN 50 for Europe, NFPA 70 - NEC North America.

These measures were developed based on the specific needs of local industries, in collaboration with manufacturers to reduce risks associated with electricity use in potentially explosive environments. In the current context of globalization manufacturers sell their products on every continent and therefore came the need for some standardization worldwide.

Due to the fact that today explosions still occur in environments where explosive atmospheres exist due to normal or accidental operating conditions, preventive measures should be taken to reduce them and even their complete removal.

For system controller, the intrinsic safety can be a new feature solution, as an example presented below.

2 Problem Formulation

Where electrical equipment is installed in explosive areas they have to be produced, designed and certified for this purpose. There are several protection methods available based on various techniques of protection:

Method	Symbol	IEC standard
Intrinsic Safety	ia, ib	60079-11
Flameproof	d	60079-1
Pressurization	p	60079-2
Increased Safety	e	60079-7
Encapsulation	m	60079-18
Oil Immersion	o	60079-6
Powder Filling	q	60079-5
Non-sparking	n	60079-15

Table 1. Method, symbol and IEC standard regarding ATEX protection methods

Intrinsic safety (*Ex 'ia' and Ex 'ib'*) is a fairly common type of protection where requirements are: limiting voltage and current.

Intrinsically safe circuits are always necessary interface as a certified zener barrier or galvanic separator for connection of the power supply from the safe are and intrinsically safe equipment located in a potentially explosive area.

Until 15 years ago, for system control of industrial process was used systems in wired logic and dynamic and static commutation.

For hazardous environment this systems have many disadvantage due to the dimension needed for special cases and the necessity of signal adaptation in order to avoid the possibility of electric spark. The uses of microcontroller eliminate some disadvantages and in some cases improve the systems parameters.

Based on the principle presented above is designed an underground controller for starting a successive sequential four motors in a potentially explosive area. The motors will start in one by one order with a delay of 1-3 second between them; each motor start will be signaled acoustically. Each motor will provides a feedback to stop operation if a failure occurs.

3 Problem Solution

For this problem solution we want to integrate the whole driving algorithm into a microcontroller and with the help of a touch screen to coordinate the entire process. With the help of the microcontroller we want to eliminate some human error.

Block diagram of the operation of this system is shown in fig 1.

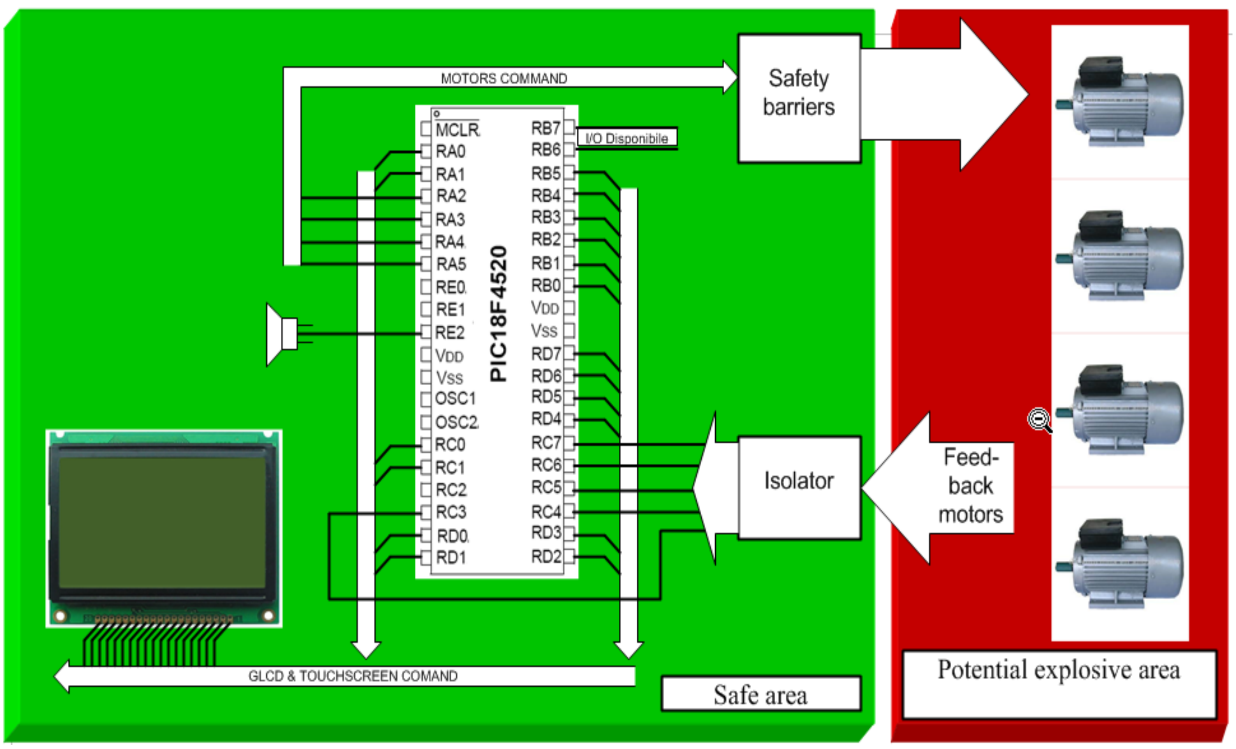

Fig.1. Description of solution for the system controller

The used microcontroller is a RISC type, PIC 18F4520, 8 bit, easy to program, with only 74 instruction, build in CMOS technology, FLASH memory and 44 or 40 pins capsule, with the low power supply meet the industrial and mining condition exigencies.

The use of the PIC's pins will be:

• From the port A, bits 2,3,4,5 are used for motor control;
• From the port C, bits 4,5,6,7 are used for feedback from motors;
• From the port C, bit 3 is used as a general failure;
• From the port E, bit 2 is used for the acoustic signaling;
• From the port A, bits 0,1 and from port C bits 0 and 1 are used to control the touchscreen;
• From the port B, bits 0,1,2,3,4,5, and all bits of port D are used for controlling GLCD screen.

Using graphic display provides for the operator interface and a good monitoring for the whole process locally.

The starting screen (fig.2) contains the START button (button that can be operated by touch screen) and motors state (which at the beginning of the application are turned off).

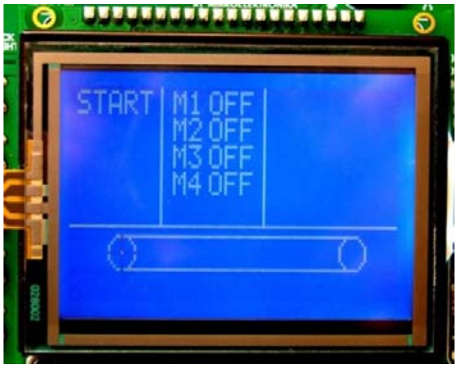

Fig.2. The starting screen

After pressing START button, it will disappear from the screen, in the upper right corner will show system status (ON), and the bottom will indicate that the motor received the command (fig.3). Before starting the motor an audible warning for 3 second will be heard, and then the system sends the command for next motor to start.

Figure 3. The command for the M1

Successful startup will be able to be watched on the screen (M1 ON) Figure 4.

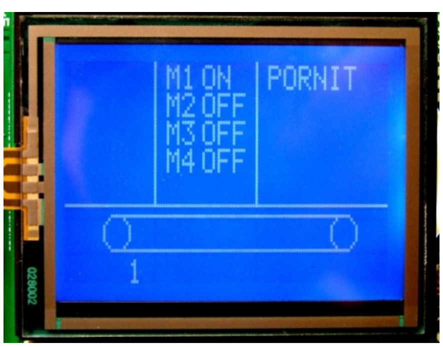

Figure 4. M1 started successfully

The same algorithm applies for the starting of the others three motors.

If there is not any general failure from any en, the system will turn on, the screen displays PORNIT SUCCES (successfully started) (fig.5.) and in the lower left corner will be visible STOP button, of which pressing will generate sequence STOP for all motors. It is available also the status of all motors in this case is all on.

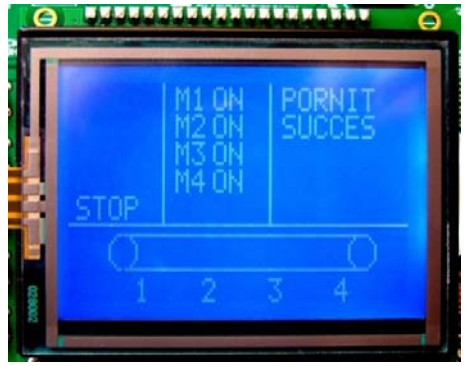

Figure 5. All engine started successfully

The system can detect and display one motor failure, in which case the system will order an immediate shutdown of all motors (fig.6). Is displayed also, where the motor malfunction is(in this case M4).

Figure 6. The motor 4 error

The STOP button will not be visible, the system returns to the initial state only after pressing the RESET button (button visible only in case of emergency). If there are other faults will only display AVARIE (failure) state. (fig.7)

Fig.7 General failure

The entire process algorithm, described above can be observed in figure 8.

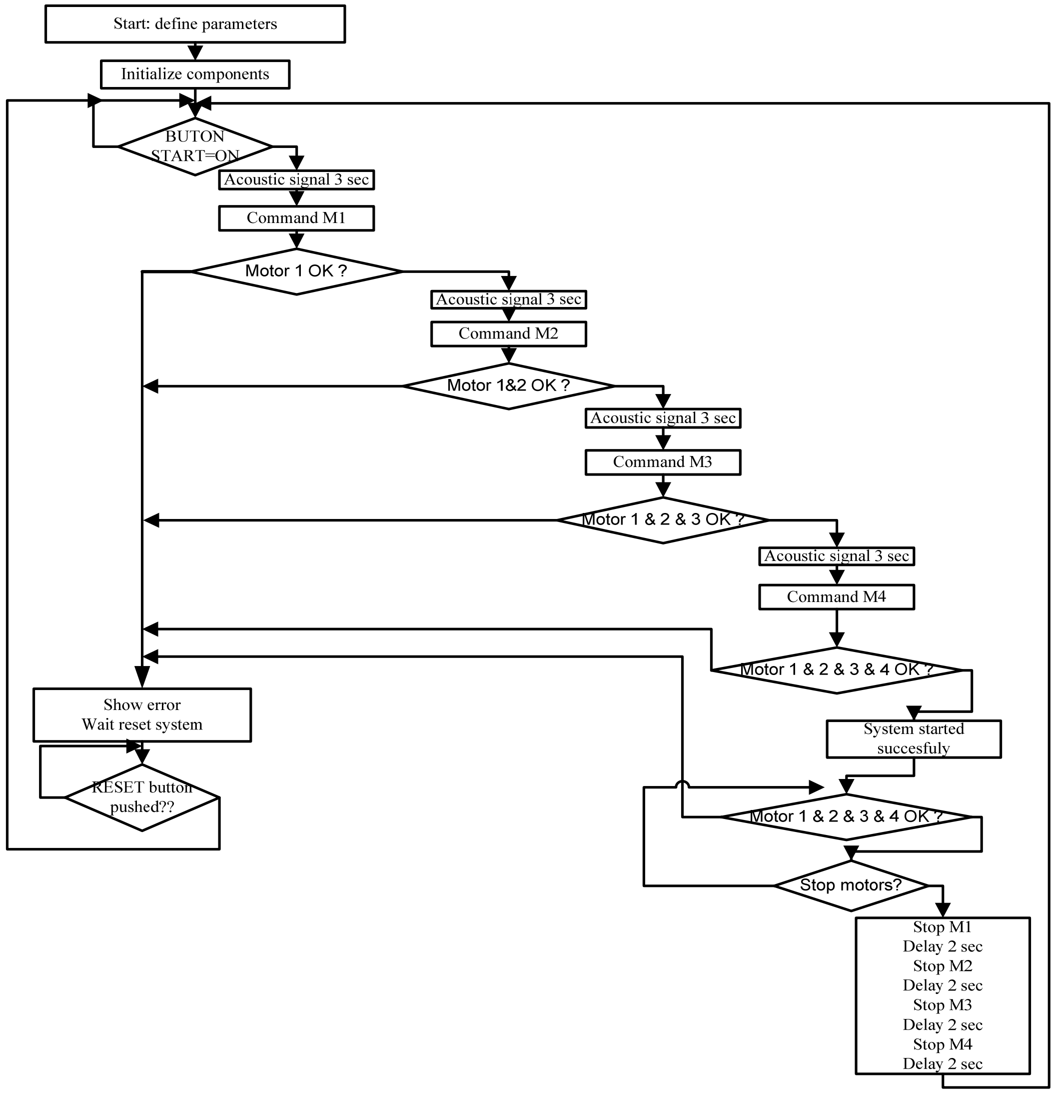

Fig.8. The safety controller algorithm

The working condition in potentially explosive area, so special equipment require between the command and the motors. In this case are designed safety barrier with zener diode. Next we will present the mathematical model of safety barriers. We consider the equivalent circuit of a barrier as fig.9

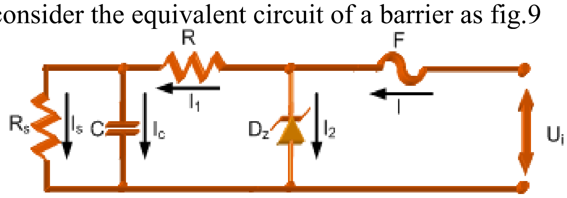

Fig.9 Safety barriers

We make the following notations:
U_i- voltage applied to barrier.
F-Fuse.
D_z-voltage limiting zener diode.
R-current limiting resistance.
R_s-resistance load.
C- capacity load.
U_z- the openening voltage for zenner diode.
I_{SC}- burning fuse current.
I- current through barrier under normal conditions.
$\Theta(Ui-Uz)$- the Heaviside distribution.
It result the I/O equation (1):

$$I = I_1 + I_2 = \frac{U_i}{R} + \left(\frac{1}{R * R_s * C} U_i - \frac{R + R_s}{R * R_s * C} I_1\right) * \frac{1}{s} + \frac{U_i}{R} * \theta(U_i - U_z) \qquad (1)$$

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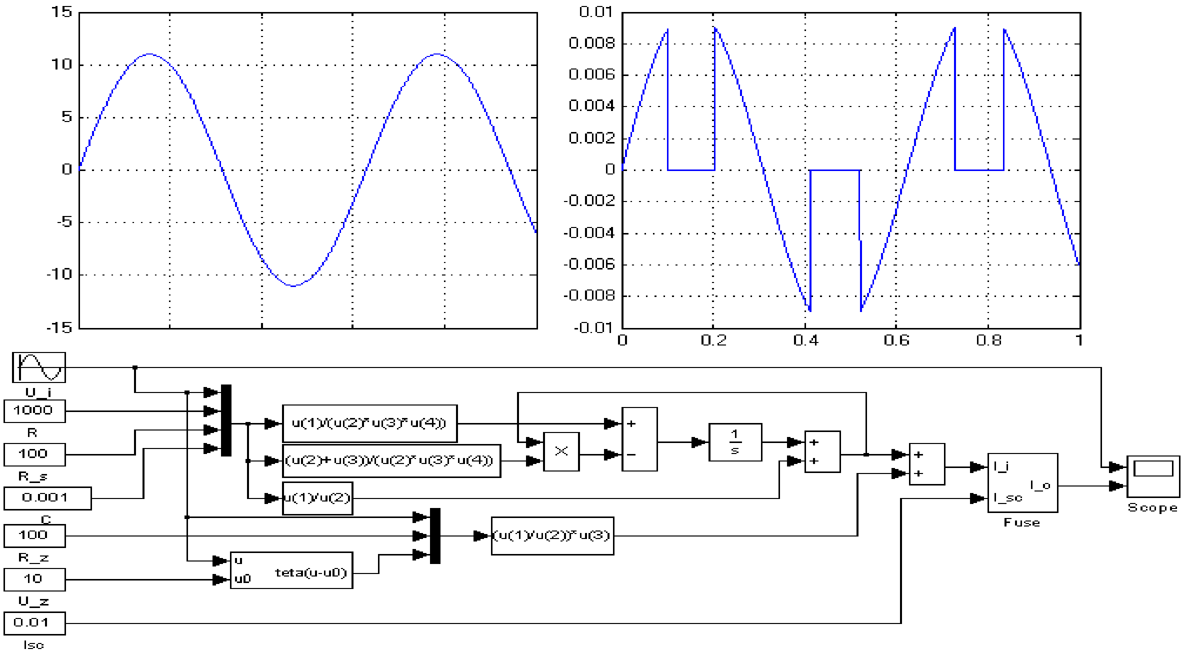

Fig.10.Modelling the safety barrier a) the simulation result b) The Matlab-Simulink model

Based on the model equation it is realized the MATLAB-SIMULINK simulation and the resulted obtained validate the proposal. (Fig 10)

4 Conclusion

Using RISC microcontroller with graphic display, assure the mining underground safety application and provides good management and a very good process observation of the controlled system. The entire system can be controlled and monitored only from this display.

The display with the touch screen provides an easy system control and a good process monitoring. By disabling the START button when an error occur, will eliminate the human factor risk, the operator cannot command the starting sequence until the error is remediate and the RESET button is pressed. A lot of other condition for safety, monitoring and control can be easy implemented.

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