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Programming (FPGA) Platform Control for Petrol Pumping

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Abstract: *the field programmable gate array (fpga) is an integrated circuit designed to be configured after manufacturing. The fpga configuration is generally specified using a verilog hardware description language (vhdl), similar to that used for an application-specific integrated circuit (asic). Fpgas can be used to implement any logical function that an asic could perform.*

Fpgas contain programmable logic components called "logic blocks", and a hierarchy of reconfigurable interconnects that allows the blocks to be "wired together"—somewhat like many (changeable) logic gates that can be inter-wired in (many) different configurations . Logic blocks can be configured to perform complex combinational functions, or merely simple logic gates . In most fpgas, the logic blocks also include memory elements, which may be simple flip-flops or more complete blocks of memory.

There are numerous options for designers in selecting a hardware platform for custom electronics design, ranging from embedded processors, application specific integrated circuits (asics), programmable microprocessor, fpgas to programmable logic devices (plds). The decision to choose a specific technology such as an fpga should depend primarily on the design requirements. Therefore, if the hardware requirements require a higher level of performance, then the fpga offers a suitable level of performance. [4]

The definition of the behavior of the fpga is performed by programming it by a very high speed integrated circuit hardware description language (vhdl).[1]

This paper deals with using the fpga as a means for petrol pumping .the embedded system based on the fpga is programmed to offer safe pumping .the fpga senses the conditions of the petrol pumping pipes in order to offer secure pumping .wireless smart sensors are mounted on the petrol pumping pipe. The aim of the design is to mainly avoid pipes damage or explosion due to mal functions of pumping.

Keywords: *fpga , vhdl , asic , pld , embedded system , petrol pumping , smart sensors.*

I. Problem statement:

Secure petrol pumping in the pipes is a challenging issue .a proposed solution is based on using multi-sensing control system based on fpga . The embedded system gives a real time response based on the data acquisition from the wireless smart sensors mounted on the pipe . The high speed of processing of the fpga offers an instantaneous response for any data coming from the smart sensors.

II. Methodology:

This paper explains the approach for the design based on the fpga platform .the aim of the complete design is to offer maximum safety for the petrol pumping process. A closed loop control system design is adapted . A number of smart sensors are installed on the petrol pumping pipe . The smart sensors provide the fpga with an instantaneous data showing the status and condition of the pipe .the sensors are connected to the fpga through a data acquisition interface circuit designed to provide the data . According to this design the fpga will be able to monitor and control the petrol pumping process instantaneously. Hence the embedded system offers a real time monitoring and control for the petrol pumping operation. The following block diagram figure (1) shows the basic parts of this design.

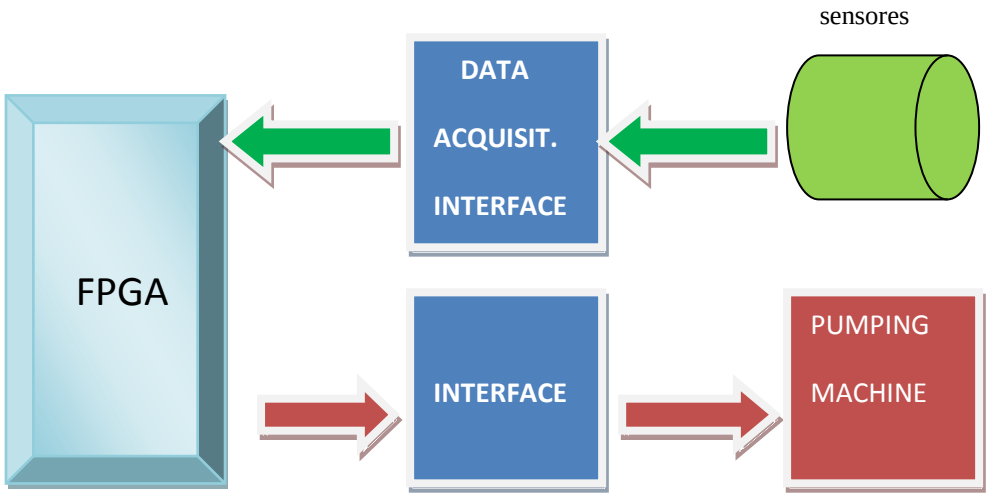

Figure (1) Block diagram for monitoring and control of the petrol pumping operation.

The electronic circuit components of the design are :

- FPGA .
- Smart temperature sensor.
- Smart pressure sensor.
- Smart rate of flow sensor.
- Data acquisition interface circuit.
- Interface circuit to control the pumping machine (Buffer + Darlington amplifiers).
- Pumping machine.

III. Objectives:

The objectives of the design are :

1. Development of a computer program in VHDL language.

2. Downloading the program into the FPGA.

3. The task of the program is to perform a real time multi-sensing monitoring and control for secure pumping of petrol in the pipes.

IV. Software Program & Algorithm:

To achieve the objective of the real time monitoring and control of petrol pumping , we need to go through five steps as follows:

1. Step one is developing a VHDL program in the computer by using Spartan-3 software .
2. Step two includes VHDL synthesis in the design, which converts the design in the behavioral description file into gates. The synthesis tools figure out what gates to be used based on the VHDL program file.
3. Step three includes downloading of the program into the FPGA as shown in figure (2).
4. Step four includes integration of the embedded platform with the smart sensors , data acquisition , interface circuit and the pumping machine as shown in figure (1).
5. Step five includes testing and debugging the operation of the whole system .

Figure (2) Connection for programming the FPGA

The algorithm for performing a real time monitoring and control of petrol pumping in the pipe contains four subroutines . The condition for calling the subroutine depends on the values acquired from the smart sensors .If the values are normal, standard subroutine will be called .If one value is abnormal , a degradation-1 subroutine

will be called. If two values are abnormal , a degradation-2 subroutine will be called. If all values are abnormal, a shut down emergency subroutine will be executed. The algorithm is Start

Initialization :

--- Clear all output control signals.
Check incoming data:
--- Check the incoming data from data acquisition interface circuit.
--- Analyze the incoming data.
--- If the [(R = N) AND (P = N) AND (T = N)] , then call standard pumping subroutine.
--- If the [(R = N) AND (P = N) AND (T ≠ N)] , then call degradation-1 emergency subroutine.
--- If the [(R = N) AND (P ≠ N) AND (T = N)] , then call degradation-1 emergency subroutine.
--- If the [(R = N) AND (P ≠ N) AND (T ≠ N)] , then call degradation-2 emergency subroutine.
--- If the [(R ≠ N) AND (P = N) AND (T = N)] , then call degradation-1 emergency subroutine.
--- If the [(R ≠ N) AND (P = N) AND (T ≠ N)] , then call degradation-2 emergency subroutine.
--- If the [(R ≠ N) AND (P ≠ N) AND (T = N)] , then call degradation-2 emergency subroutine.
--- If the [(R ≠ N) AND (P ≠ N) AND (T ≠ N)] , then call shut down emergency subroutine.
--- Go to check incoming data .
End.
Standard pumping subroutine :
Start:
--- Set the petrol pumping machine to the standard RPM based on the specifications of the pipe (1000 RPM).
Return.
Degradation-1 emergency subroutine :
Start:
--- Set the petrol pumping machine to (25 %) reduction of the RPM (750 RPM).
Return..
Degradation-2 emergency subroutine :
Start:
--- Set the petrol pumping machine to (50 %) reduction of the RPM (500 RPM).
Return..
Shut down emergency subroutine :
Start:
--- Shut down the petrol pumping machine (0 RPM).
Return..
FPGA connector A1 is programmed for data acquisition from the smart sensors on the pipe.
FPGA connector A2 is programmed for data output to control the RPM of the petrol pumping machine.

V. Results

The FPGA is the right choice for the operation of petrol pumping process despite its high cost relative to other processors .The FPGA has huge facilities to control systems according to its ability to execute the commands in a parallel way. This criteria widens the range of controlled elements with less delay time. The same thing in VHDL language, in spite of its complicated language, but we think that it is the right choice to program complicated control systems. It is suitable for a system that needs fast execution of commands.
.The designed monitoring and control system is a real time system. It operates and responds according to the data values acquired from the smart sensors (temperature (T) , pressure (P) and rate of flow(R)).
Table (1) below shows the results of operating the system.
Equation (1) , (2) , (3) show the relation of (RPM) to the three sensed parameters.

$$RPM \quad \alpha \quad \left(\frac{1}{T}\right) \times \left(\frac{1}{P}\right) \times \left(\frac{1}{R}\right) \qquad \text{---------- (1)}$$

$$(RPM)_{STANDARD} = (T)_N \text{ AND } (P)_N \text{ AND } (R)_N \qquad \text{---------- ----- (2)}$$

$$\text{SHUT DOWN } (RPM = 0) = (T) \neq N \text{ AND } (P) \neq N \text{ AND } (R) \neq N \qquad \text{---------- (3)}$$

Where;
T = Temperature , P = Pressure , R = rate of flow .
N = Normal , ≠ N = Not normal , RPM = Revolution per minute .

Rate of flow sensor (R) m/s	Pressure sensor (P) mb.	Temperature sensor (T) 0 C	(RPM) of pumping Machine (rev/m)

NORMAL	NORMAL	NORMAL	**1000 (STANDARD)**
NORMAL	NORMAL	EXCESSIVE - T	750
NORMAL	EXCESSIVE – P	NORMAL	750
NORMAL	EXCESSIVE – P	EXCESSIVE - T	500
EXCESSIVE - R	NORMAL	NORMAL	750
EXCESSIVE - R	NORMAL	EXCESSIVE - T	500
EXCESSIVE - R	EXCESSIVE – P	NORMAL	500
EXCESSIVE - R	EXCESSIVE - P	EXCESSIVE - T	**SHUT DOWN**

Table (1) Results of operating the system under all possible conditions.

VI. Conclusion

A problem usually has multiple solutions, and a process can usually be controlled using different controllers based on different methods. Almost every control method has its merits and weaknesses. What is important is to use the right controller to fit the application at a minimum cost.

In the recent years, there has been a technical revolution in the semiconductor industry and in the electronics industry, which has significantly developed the existing technologies in industrial control.

This technical development in both the semiconductor and the electronics industries have evolved industrial control into both real-time control and distributed control. Real-time control requires controllers to capture all the significant target activities and to deliver their responses as swiftly as possible so that system performance is never degraded. Distributed control indicates that controls are performed by a number of controllers and executed in a group of independent agents or units that are physically and electronically connected and communicate with each other. This tendency in industrial control has led to the future continuation of both real-time control and distributed control.

The (FPGA) have now approached intelligence similar to that of microprocessors, so that they are performing more important functional role in various control systems. In this paper petrol pumping is considered .The FPGA plays the intelligence role in monitoring and control operations.

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