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FPGA Implementation of Automatic Irrigation and Pesticide Control System

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ABSTRACT

In many parts of the world rainfalls are inadequate to meet agricultural needs of farmers. It thus becomes imperative to use an irrigation system that meets the moisture needs of plants in order to increase food crop production. The system described here monitors the moisture and pesticide control needs of crops. Irrigation control is monitored through suitable moisture sensors and automatically pumps water when the need arises through FPGA control logic thus requiring minimal human interventions. We can also use this system for liquid pesticide supply through the selection. Thus, we achieve the efficient supply of water and pesticide as needed by plants and conserve quantity, energy and time. In this paper, the proposed system is designed using Verilog and implemented on FPGA. The system operation is also explained in DSCH (Digital Schematic) software. The system is very simple to operate and ideally suits the irrigation and pesticide need for green houses as well as farms.

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1. INTRODUCTION

India is an agriculture–oriented country. Irrigation provides enough moisture essential for plants, and also protects against drought and cools the soil and atmosphere to provide a convivial environment for plant growth [1]. Irrigation is carried out mainly through the use of surface or flood irrigation and the drip irrigation type. The drip irrigation has many advantages over basin flood and localized methods of irrigation [2]. Water soluble fertilizer can also be applied without any wastage by this irrigation system.

Usage of technology in the field of agriculture such as automated irrigation systems significantly contributes to the increase in the crop production, reduces the extra man power efforts and conserves water. For the real time application of agriculture technologies, low cost and real time monitoring are needed. There are many existing systems, to meet the moisture needs of green houses, using microcontrollers. Though these systems are reliable, they lack flexibility to reprogram it. Thus, an efficient and flexible irrigation system, with automatic control is necessary. In this sense, programmable Logic Devices (PLDs) present as a good option for the technology development and implementation, because PLDs allow fast development of prototypes and design of complex hardware systems using FPGAs (Field Programmable Gate Arrays) and Complex Programmable Logic Devices which are reprogrammable [3]. The System proposed in this paper, uses moisture sensors, whose outputs are sent to FPGA control unit, which drives the tap control is necessary. In this sense, programmable Logic Devices (PLDs) present as a good option for the technology development and implementation, because PLDs allow fast development of prototypes and design of complex hardware systems using FPGAs (Field Programmable Gate Arrays) and Complex Programmable Logic Devices which are reprogrammable [4], [5]. The System proposed in this paper, uses moisture sensors, whose outputs are sent to FPGA control unit, which drives the tap control. To perform this, appropriate sensors must be used.

2. RESEARCH METHOD

2.1. System Description

In the proposed system, we use the automation, which controls the irrigation and Pesticide supply of 16 greenhouses or 16 farm pieces. We use 16 moisture sensors, whose outputs are digital and given as FPGA inputs. The FPGA is control circuit whose outputs are given to four taps each attached with four valves, using solenoid drive. The field diagram of the system and the block diagram of the system are shown in the figure 1 and figure 2 respectively.

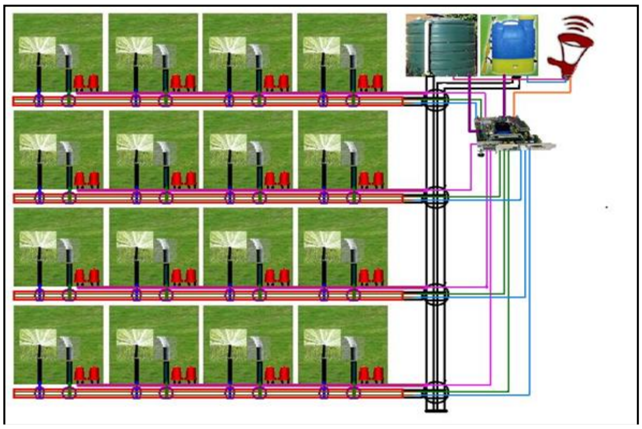

Figure 1. FPGA implemented field diagram of the system

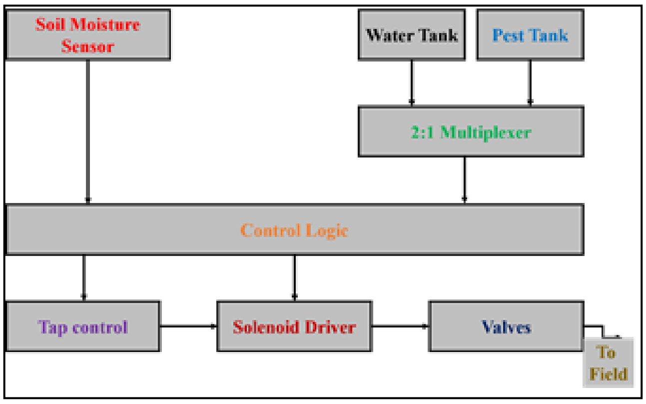

Figure 2. Block diagram of water-pesticide control system

This system consists of a 2:1 Multiplexer with two inputs and one output with a single selection line is used to select between water supply or pesticide supply and farms are irrigated according to the sensor output logic. The system also consists of two error signals indicating the availability of water and pesticides in the tank. Irrigation system uses moisture sensor outputs to determine the necessity of the water.

2.2. Soil Moisture Sensors

Soil moisture sensors measure the water content in the soil. They measure the soil moisture by measuring the properties like electrical resistance, dielectric constant and interaction with neutrons out of which a few are mentioned here. The dielectric constant of soil, is an electrical property which has a high influence on the moisture content in the soil. The dielectric constant for dry soil is between 3 and 5. Change in moisture content causes substantial variation in dielectric constant. The relation between the measured property and soil moisture must be calibrated. Capacitive Sensors and Time Domain Reflectometry (TDR) are the most commonly used Dielectric devices.

2.3. System Implementation

If the water-pesticide control switch is LOW then if any out of total 16 sensors, any of the four sensors in a row is ON, then the tap corresponding to the row opens and water flows to main pipe. The water is let into only those fields whose sensor is ON by driving valves according to sensor outputs. When water-pesticide control switch, (MUX selection) is HIGH, then liquid pesticide flows through the pipes all over the farm, with all taps and valves open.

The two error signals indicate the availability of water and pesticides in the tank. If water tank is empty, then the error signal goes high indicating a red LED-1 ON. Similarly, if pesticide tank is empty, then another error signal goes high indicating red LED-2 ON. When this happens, simultaneously all valves and taps are closed

3. RESULTS AND ANALYSIS

A Verilog code is written for the proposed control system and synthesized. The synthesis report is as follows:
Advanced HDL Synthesis Report
Macro Statistics: no macro
Timing Summary:
% Speed Grade: -4
No clock
Maximum combinational path delay: 7.04ns.

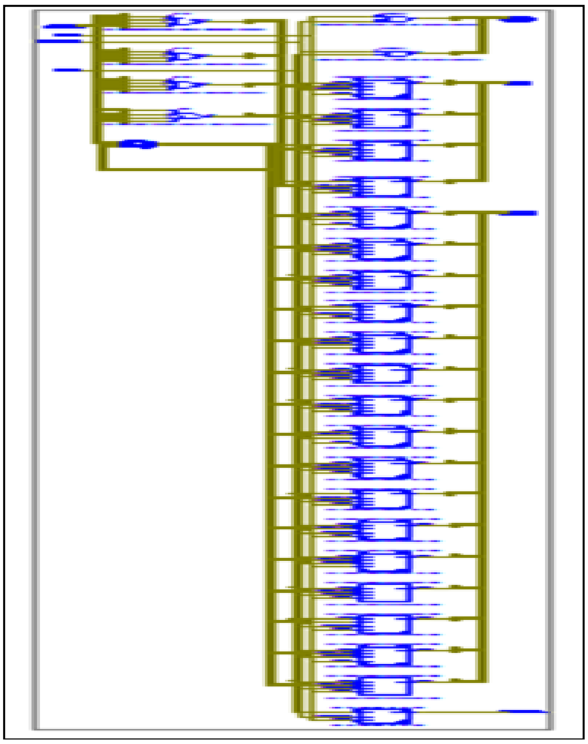

Figure 3. Schematic diagram of RTL

3.1. Synthesis and Simulation

A Verilog code is written for the proposed control system and synthesized using Xilinx as shown in figure 3 and implemented on FPGA. A part of the proposed system, i.e. single row with four sensors, four valves and one tap is implemented. The FPGA board used is DIGILENT NEXYS 2. It has eight switches as inputs (four sensors, water-pesticide control, water tank, pesticide tank) and eight LEDs indicating the outputs (four valves, one tap, two error bits, and water-pesticide control indicator). These results are shown figure 4.

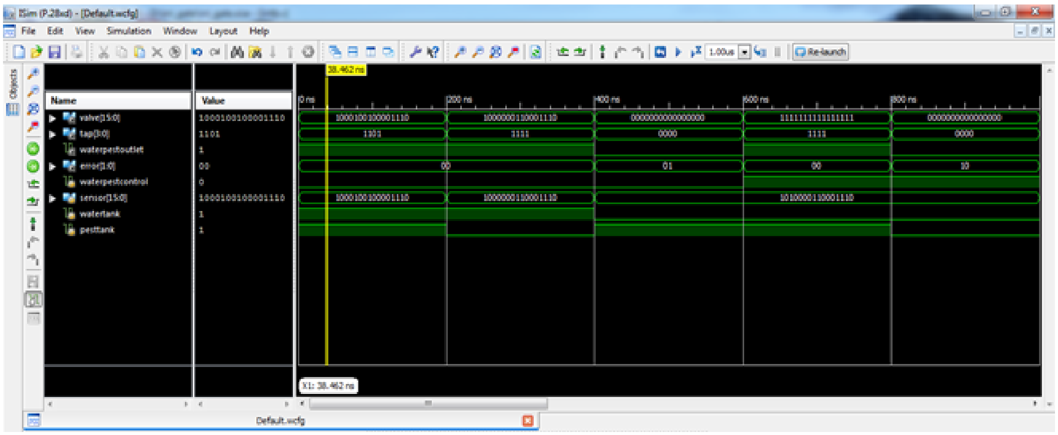

Figure 4. FPGA simulated signals

To meet high demands of production, it is necessary to adopt optimized farming techniques. Hence, it is very important to use an efficient irrigation system to preserve water sources, minimize wastage of pesticides or other liquid fertilizers and also reduce human effort. The proposed system is very fast (Maximum combinational path delay: 1.237ns), less complex, and low cost. As we implemented this on FPGA it is reprogrammable and hence more flexible.

(a) (b) (c)

Figure 5. (a) Water tank control indication, (b) Pesticide tank control indication and (c) Error signal indication

The figure 5(a) shows the result for the inputs when water tank is filled i.e HIGH, water pest control is LOW, valves 2 and valve 3 are HIGH and corresponding tap is HIGH. The figure 5(b) shows the result for the inputs when pesticide tank is filled i.e HIGH, water pest control is HIGH, valves 1 to 4 and corresponding tap is HIGH. And the figure 5(c) shows the error caused due to selection of empty water tank by MUX. Due to this all other valves and taps are closed and error signal is indicated.

3.2. Device Utilization Summary

Number of Slices: 16 out of 4656 0%
Number of 4 input LUTs: 27 out of 9312 0%
Number of IOs: 49
Number of bonded IOBs: 42 out of 232 18%
Cell Usage:
BELS : 27
LUT2 : 2
LUT3 : 1
LUT4 : 24
IO Buffers : 42
IBUF : 19
OBUF : 23

4. CONCLUSION

In this paper, we have demonstrated a 4 x 4 array sensors water-pesticide control system using Verilog and implemented on FPGA. We have simulated irrigation control is monitored through suitable moisture sensors and automatically pumps water when the need arises through FPGA control logic thus requiring minimal human interventions. Using this method of FPGA implementation we are able to control the efficient supply of water and pesticide as required by plants and conserve quantity, energy and time. Also the system developed through the digital schematic software.

REFERENCES

[1] Zhiyong Lai, Yongli Dai, "*An Irrigation Control System Based on an FPGA*". Published in Instrumentation, Measurement, Computer, Communication and Control (IMCCC), 2012 Second International Conference, Harbin, Print ISBN 978-1-4673-5034-1.

[2] Jonathan A. Enokela1, Isaiah I. Tsavwua, Simon A. Onyilo, "The Implementation of a Control Circuit for Microcontroller based Automated Irrigation System". *International Journal of Emerging Technology and Advanced Engineering*, ISSN 2250-2459, ISO 9001:2008 Certified Journal, Volume 4, Issue 6, June 2014.

[3] Swarup S. Mathurkar, D. S. Chaudhari, "A Review on Smart Sensors Based Monitoring System for Agriculture". *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, ISSN: 2278-3075, Volume-2, Issue-4, March, 2013.

[4] Aniket H. Hade, Dr. M.K. Sengupta, "Automatic control of Drip Irrigation systems and Monitoring of Soil by Wireless". *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS)*, e-ISSN: 2319-2380, p-ISSN: 2319-2372. Volume 7, Issue 4 Ver. III (Apr. 2014), PP 57-61.

[5] M. Dinesh, P. Saravanan, "FPGA Based Real Time Monitoring System for Agricultural Field". *International Journal of Electronics and Computer Science Engineering*, ISSN- 2277-1956.