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FPGA Implementation Of Irrigation Control System

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Abstract— The paper FPGA implementation of irrigation control system is mainly focused on controlling the irrigation system at the same time it will care the crop in all aspects for the benefit of agricultural system and provides sufficient irrigation in particular field. It consists of different sensors that are interfaced with FPGA. The sensors will monitor the field conditions, and the sensors information will be stored in memory. Here the farmer will take the required information and he can take necessary precautions to his fields. The parameters for different devices were compared. By using HDL language the overall system architecture was designed. The simulation and synthesis are done using EDA tools.

Index Terms— Field Programmable Gate Array (FPGA), Flash memory, Sensors, EDA tools, HDL

1 Introduction

Farmer is the back bone of Indian economy. Agriculture in India has a significant history. The cultivation of crops is much needed for the survive of human kind. India is well known for its agricultural work. It plays a crucial role for providing employment to most of the people. The development of agriculture is considered to be necessary for the advancement of the countries from traditional to modern economy. Almost all the farmers are still depending on the traditional way of cultivation. We are observing that the yield of crops and fruits are not at all being increasing. The farmer is facing a lot of difficulties while irrigating the fields. These complications will be abolished by automating the irrigation system. By doing this we can increase the yield and quality of the crop. For this a new system was proposed in this paper to improve the irrigation system. By using this system the farmer can monitor soil moisture, water level, and temperature, humidity, and dew point sensors for the better cultivation of the crop. The required control system is designed in XILINX 6 -series FPGA using VelogHDL. The sensors are integrated to the FPGA through in built A/D converter (ADC). The communication between various devices takes place through RS232. Simulation and synthesis are performed to the remote monitoring system by using suitable tools and analyzing the performance of the system by comparing speed constraints.

2 System Diagram

This system will monitor all these parameters through different sensors. Soil moisture sensor will measure the water content in the soil i.e.; it will check whether the soil is dry or wet. Water level sensor senses the water in the water source. Temperature sensor and humidity sensor are used for forecasting the weather conditions. Dew point sensor will convert the water vapor into liquid state.

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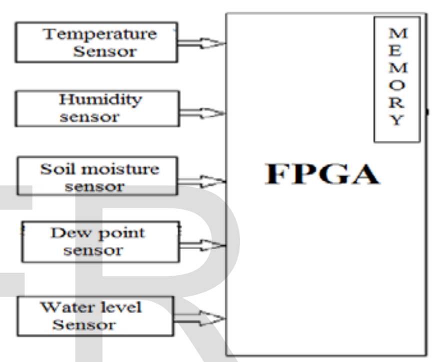

Fig. 1 system architecture of irrigation control system

When any of the climatic parameters like temperature, humidity, water level, soil moisture and dew point etc. cross a safety threshold which has to be maintained to protect the crops the sensor sense the change and the FPGA reads this data at its input ports after being converted to a digital form by the ADC .The FPGA then performs the needed actions. As the system also employs memory in which all the sensor values are stored.

2.1 Temperature sensor:

A temperature sensor is used to measure the temperature of the fields. This is most effective field parameter which has greater influence on other parameters.

2.2 Humidity sensor:

Humidity is the presence of water in air. In agriculture, measurement of humidity is important for plantation protection and soil moisture monitoring. The humidity sensor is also called a hygrometer. It continuously measures and reports the relative humidity in the air.

The humidity sensor senses relative humidity. That means it measures both air temperature and moisture. Relative humidity is expressed as a percentage. It is the ratio of actual moisture in the air to the highest amount of moisture air at that temperature can hold. The warmer the air is, the more

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moisture it can hold, so relative humidity changes with fluctuations in temperature.

2.3 Dew point sensor:

Dew point temperature is measured in (°C or °F). Dew point is the temperature where condensation begins, or where the relative humidity would be 100% if the air was cooled.

2.4 Soil moisture sensor:

Soil moisture sensor measures the water content in soil. Measuring soil moisture is very important in agriculture to help farmers manage their irrigation systems more efficiently. Farmers able to generally use less water to grow a crop, they are able to increase yields and the quality of the crop by better management of soil moisture during critical plant growth stages.

3 Xilinx FPGA Description

The virtex 6 FPGA has less delay when comparing with other FPGA devices like Spartan 3E, virtex 4and virtex 5.Virtex 6 is more efficient. The main features of this FPGA is it has a 12 bit 1Msbs analog to digital convertor inbuilt XADC, having 16 external user configurable analog input channels. And by using this we can connect 16 analog sensors at a time and store all parameter values in a PROM memory.

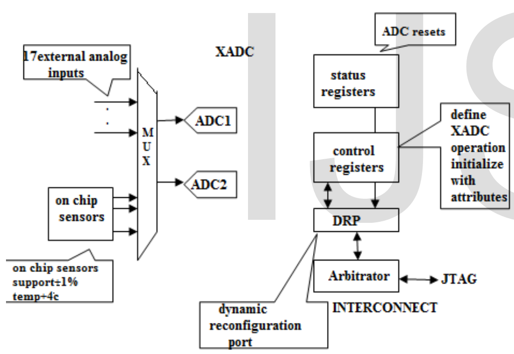

Fig. 2 XADC overview

The XADC contains dual 12 bit 1Mpbs analog to digital converter. It has 17 analog user configurable inputs. It has on chip thermal and supply sensors. .it is having a track and hold amplifiers, which will supports a range of analog input signal types, which includes unipolar, bipolar, and differential. These analog inputs will support the signal bandwidth of atleast 500 kHz at the sample rates of 1Msbs. It has the basic on chip and power supply rails

4 Sensor to FPGA Interfacing

Agriculture sensors which are used to analyze different field parameters are interconnected to a 6- series FPGA kit which contains 17 external analog input pins. Mostly 16 sensors are connected at a time by using the above kit. By changing this analog results into digital and obtain the related field parameter values and get this value at the end of FPGA core in 6 series FPGA kit. Then we can store this values in ROM memory by using FPGA to prom memory interconnect. We can store all these results in the external ROM memory.

In agriculture there exist different threshold limits to all parameters like temperature, Humidity, dew point, water level and soil moisture etc. If the values stored in the registers of the FPGA board crosses the threshold limits then all the field parameters values will be stored in memory.

5 Memory Interfacing

The field-programmable gate arrays (FPGA) has on chip memory. It has the routing structure between the memory arrays and logic resources. For the maximum flexibility and better performance, a PROM flash memory is connected externally to the FPGA, which is used for storing the data. The flash memory is used for storing the various samples which are coming out from LASER beam through ADC. From the flash memory we can compare different multiple samples and the required data will be passes through DDS interface. The memory interface for an FPGA-based design have three fundamental building blocks: the Read &Write and Data interface, the memory controller state machine, and the user interface that bridges the memory interface design to the rest of the FPGA design. The user sends a command read or writes along with the address and data for write, the Memory interface clocking requirements are typically more difficult to meet when reading from memory, as compared with writing to memory.

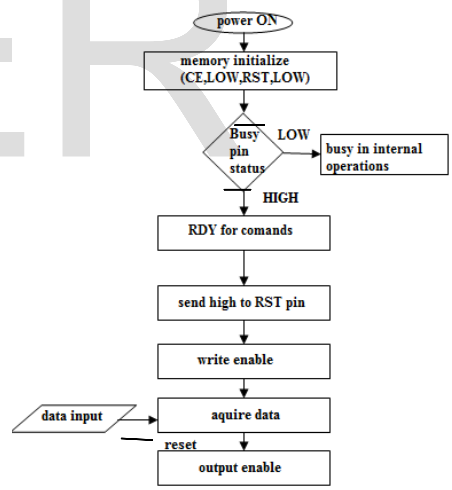

Fig.3 Flow chart for Flash Memory

When the power is ON, the FPGA will send low signal to the RST pin. When it was active the RST pin will set the device in to read array mode. And hence the data can be read by sending a high signal on RST pin and making CE-low, OE-low, WE-high, after completion of one cycle the FPGA reads the BUSY pin, a LOW on this pin indicates that it was performing some internal operations. And HIGH on this will indicates it was RDY to receive new commands. And similarly when the RST pin is HIGH we can WRITE the data.

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6 Results

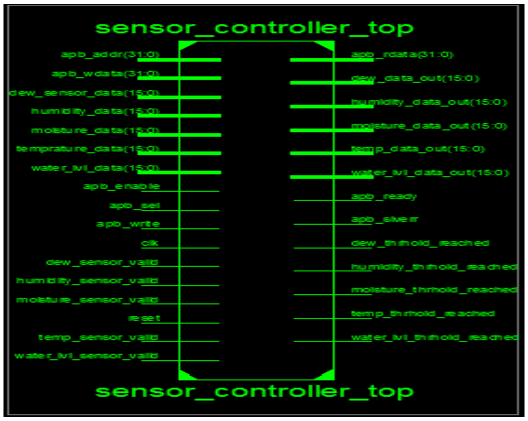

Fig 4: RTL Schematic Diagram of sensor controller and memory

The above fig 4 shows the RTL schematic diagram of all the sensors and memory interface in which one can clearly observe the sensors inputs and outputs.for fpga temperature sensor data,soil moisture data,humidity data,dew sensor data were given as inputs to the fpga,moreover the memory signals like enable,select,write,read signals were given as input.whenever all the sensors crosses its threshold limit that output will be given to the soil moisture data out,humidity data out,dew data out,water level data out,temperature data out signals respectively.

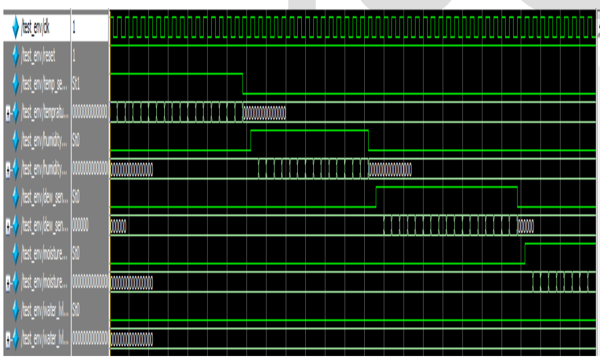

Fig 5: simulation waveform for all sensors

The above fig 5 shows the inputs that are given to the sensors. Here all the sensors will take the digital values as its inputs, and it will check with the threshold limit whether it was crossing the limit or not.

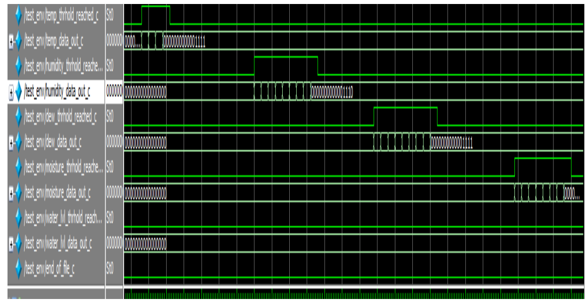

Fig 6: Simulation waveform for sensors

The above fig 6 shows the simulation waveform for the outputs of the sensors. Here if the sensor crosses the threshold value that result will be displayed as its output.

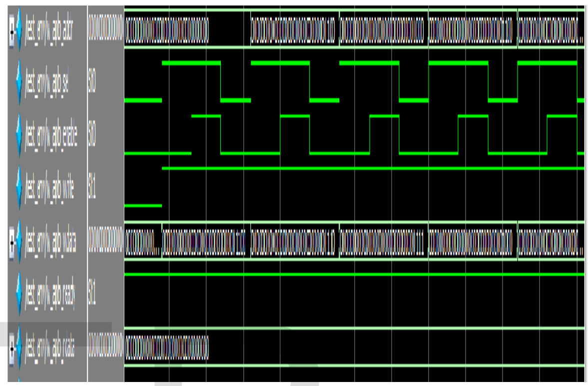

Fig 7: simulation waveform for memory

Fig 7 shows the simulation waveform for memory. Here whenever all the sensors cross its threshold value that information will be stored in memory

Table 1: Parameters Analysis Report

S.NO	DEVICES	DELAY(NS)	SLICE REGISTERS	LUTS
1	SPARTAN 3E	10.98	277	267
2	VIRTEX 4	8.411	277	267
3	VIRTEX 5	5.931	310	180
4	VIRTEX 6	3.209	310	180

Table 1 shows the comparison of different devices for parameters like delay, slice registers and LUTs. The delay is decreased when compared to Spartan 3E to vertex 6 as shown in table 1. By using vertex 6 the execution time is very less when compared to other devices

7 CONCLUSION

FPGA implementation of irrigation control system leads to the improvement in yield of the crops. The system will monitor all the field parameters thus providing the necessary information to the farmers. It becomes very efficient to use in rural areas. The use of FPGA facilitates the system for re-configurability and re-programmability according to different environmental conditions. The usage of this FPGA enhances the application area of sensor networks in all agricultural environments by improving the speed of operation. In future these collected fields parameters data can be send to the farmer through wireless networks.

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