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WEATHER MONITORING SYSTEM USING FPGA

[1]Ankith M G, [2]Adithya Raj Khathi, [3]Likhitha, [4]Gowtham, [5]Swapna Srinivasan

[1]Student,[2]Student, [3]Student, [4]Student, [5]Senior Assistant Professor

[1] Department of Electronics & Communication Engineering,

[1]Mangalore Institute of Technology & Engineering, Moodabidri, India

Abstract: In recent times changes in weather are unpredictable due to drastic changes in solar activity, greenhouse gas emissions etc. A system to monitor the changes in the weather conditions in industry, agriculture etc. in real time is facilitated by a Weather Monitoring system. Monitoring temperature and relative humidity by using the sensor helps for weather forecasting. Our aim is to outline a low power electric circuit to be implemented along with a Field programmable gate array for functional verification and performance estimation. For real time weather monitoring a device is presented to report relative humidity and real-time temperature using FPGA board**.**

Index Terms **- FPGA (field programmable gate array).**

I. INTRODUCTION

Monitoring real time weather is plays a crucial role in one's life as we all know, is extremely important to India's economy. Agriculture accounts for almost a quarter of India's GDP. Agriculture, hospitals and industries need to measure the temperature and relative humidity for their research, production and to diagnosis of patients etc. Humidity can affect human health because it affects our thermal comfort and also affects the growth of greenhouse gases. In this circumstance, knowing the weather forecast is critical before sowing or harvesting the crops. As a result, farmers would benefit from weather monitoring through the use of a weather monitoring system. Use of single sensor is found to be effective to measure temperature and relative Humidity. This project mainly helps the farmers to know the climate condition for crop cultivation. The monitoring system used here can be static or portable. The static monitoring stations are generally introduced at various geological areas to screen the required parameters and continuously send the gathered information to PC through Wi-Fi module.

II. LITERATURE REVIEW

In this paper they explained implementation of FPGA and how the FPGA hardware is used to obtain the data from anywhere each and every time. In this paper the main objective is to save data in the cloud which helps in retrieving the data from anywhere this made the maintaining cost low. They showed various usage of the device in places like food industries and etc. [1].

The author proposed in this paper that how the monitoring of weather plays an important role in one's day to life. They used the model of client -server using IoT. The two-tier architecture is used in the system. They showed that how the data is sent by the sensor to serial monitor which is an Internet Protocol address and how the HTTP server is utilized to retrieve the data. Here they also show the obtained data the web page [2].

In this the authors aim was to design and build a prototype of weather station. So, they can collect the data of weather parameters like speed and direction of a wind, temperature and humidity, ozone gas and the amount of rainfall. The data is transferred to the MySQL database via the Narrowband Internet of Things using the Constrained Application Protocol. [3].

The objective of this paper is that using three sensors (temperature, humidity and CO2) for experiment to show the faster functionality and circuit integrity and fast the response of the device which use the design of ASCI in FPAA and FPGA for weather monitoring. [4].

In this paper, authors shown that weather conditions are changing day by day how it can be monitored using the weather monitoring system. This is system monitors the changes occurring which are controlled in the areas like agriculture, house and industries using IoT and the other platforms like ThingSpeak.[5]

III. METHODOLOGY

Spartan FPGA is a flagship product series from Xilinx. It offers system integration and system performance optimization. FPGAs represent crucial semiconductor devices that depend on the CLBs (configurable logic block) matrix and get connected through programmable interconnects. Most ultra-modern electronic applications need extraordinary capacity, bandwidths, and high-performance processor technology. In most instances, such electronics need a small FPGA footprint as well. Xilinx Spartan FPGA is one such processor component that will always cover these bases, making it ideal for consideration when designing and developing high-end computing electronic products. Xilinx Spartan FPGA is a type of programmable logic device that is used for designing embedded systems and electronics.

The main board and the command centre are two main units of the system. PC is the control centre which is connected to Spartan 3 FPGA through RS232 serial communication port The controller unit, which is implemented in Spartan 3 FPGA, the sensor circuit, and the Wi-Fi module are the three system board units which are connected to Spartan 3 FPGA, where sensor provides necessary readings of temperatures and it is transferred to PC through Wi-Fi module.

We install the system board in a remote location to monitor humidity and temperature. When the temperature and moisture content are measured by the system board and compared to a threshold value in the command centre, a warning is displayed if the temperature or humidity exceeds the threshold value. The controller is the system board's main unit, which was designed in Verilog HDL and tested on a Xilinx Spartan 3 FPGA.

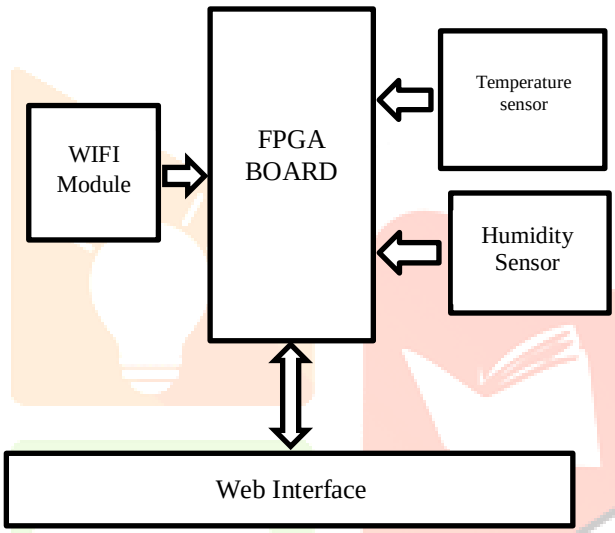

figure 1. block diagram

IV. COMPONENTS

[1] SPARTAN-3 FPGA BOARD:

Spartan 3 FPGAs come in five different platforms, each with its own for low-cost applications, an expense combination of microcontroller connections and specialized hard IP is used. Spartan 3 is utilized in applications that require the maximum density and check the pins Ideal for computation applications that require a lot of integration. The Spartan-3 FPGA has an expansion port plugs in one or more boards to plug into the expansion bus. The programmable logic of the FPGA contains resources such as memory blocks, DSP slices, and mega-flops. A mega-flop is a unit of logic that executes one million floating-point operations per second. We can use logic resources in FPGAs with multiple different combinations to fulfil different design needs. We combine the Spartan-3 family with a number of small resources to minimize the design's pin count. As a result, the RAM block is configured as a memory block that provides additional storage and random-access memory to the embedded system's components. Other FPGA families utilize more power than the Spartan-3 family. When executing a 1 MHz operating point, for example, the gadget requires less than 1 W of power (BOD level). Even when used intensively, such as during simulation, the gadget consumes less than 0.5 W of electricity. For storing huge amounts of data during FPGA simulation, the Spartan-3 family provides a big RAM block that can store up to 1 GB of data. We can simply access and debug the RAM block by detaching it from the main calculation zone. A configuration block at index 8 in the configuration file can be used to set the relative size of the RAM block. he logic of the Spartan-3 family has an optimization using Xilinx's tools. This reduces the amount of logic needed to perform a specific task. The Spartan-3 family has a fast boot time because it has an internal configuration memory loaded by the circuit board at the start-up. These speeds up the configurations process to allow users to start using their designs quickly. Due to design predictability, the Spartan-3 series can reduce existing design iterations. Because the gadget employs FPGA capabilities rather than general-purpose logic parts, this occurs. The time it takes to redesign a design is reduced when the number of iterations required to implement new designs is reduced. From low-frequency communication blocks, the Spartan-3 series offers a variety of applications. For example, high-performance communication blocks in radios and communication equipment are employed in modems. Low-frequency control capabilities are also supported by the devices. Central processing units (CPUs), digital signal processing (DSP), high-frequency fixed-point DSPs, and floating-point DSPs, for example.

figure 2. FPGA spartan-3 board

[2] DHT11 SENSOR:

The DHT11 is a popular temperature and humidity sensor that features a dedicated NTC for temperature measurement and an 8-bit microprocessor for serial temperature and humidity data output. The requirements are 3.5V to 5.5V operating voltage and 60uA operating current (measured) 0.3mA. (standby) Serial data is the output. Temperature range is 0°C to 50°C, relative humidity is 20% to 90%, and both humidity and temperature have a 16-bit resolution. 1 ° C with 1% accuracy Because the DHT11 sensor is calibrated well, transmits serial data, and is simple to set up. Temperature and humidity measurement, local weather stations, environmental monitoring, and autonomous climate control are some of the applications.

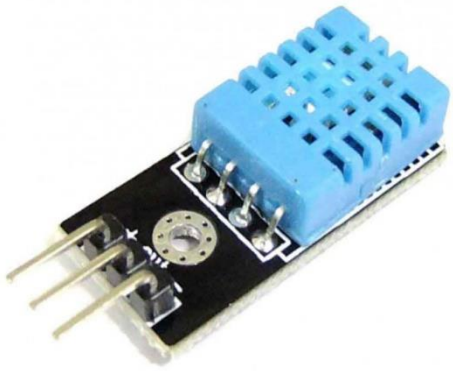

figure 3. DHT11 sensor

[3] ESP8266 WIFI MODULE:

The WIFI Module has a limit with an inbuilt Transmission Control Protocol/Internet protocol stack that allows any microcontroller to connect to your WIFI connection. The ESP8266 can run an application or delegate all WIFI networking tasks to another processor. Each ESP8266 module comes pre-programmed with AT command set firmware, allowing you to plug it into your Arduino and have nearly the same amount of WIFI functionality right away! The WIFI module is a low-cost board with a growing number of users.

Onboard processing and storage capacity allow this module to be employed with sensors and other usage of specific devices. Functions such as TR switches, baluns, LNAs, power amplifiers and respective networks are all integrated into the WIFI Direct (Peer-to-Peer) 802.11. All PLLs, regulators, DCXOs and power plane supports are integrated. The output power in 802.11b mode is +19.5 dBm. Reduce the leakage current by 10uA. As an application processor, a 4Megabytes Unified 32bit Low Power Processor can be utilized AMPDU and AMSDU 1.1/2.0 composite data with guard interval of 0.4ms, sub-2ms wake and packet transfer, 1.0mW sleep capability (DTIM3).

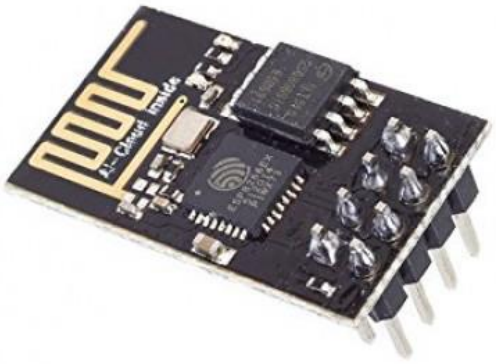

figure 4. ESP8266 WIFI module

V. RESULTS

DHT11 Humidity Temperature Sensor varying temperature and humidity information of the environment are captured by the DHT11 component. It is a Temperature and Humidity Sensor which has a calibrated digital signal output. The DHT11 ensures a high reliability and long-term stability by using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology. With a resistive-type humidity measurement component and a temperature measurement component, the DHT11 provides a reliable data. Its element is calibrated in the laboratory under extremely accurate humidity calibration conditions and stores the calibration coefficients in memory as programmed for later use. The temperature and humidity sensor used for this study has a coverage range of up to 20 meters. It complies with standard reference temperature for industrial measurement which is given as 20 0 c – 25 0 c.

The FPGA spartan 3 was used in developing the sketches that were uploaded as firmware into the microcontroller. The code is written in Verilog HDL language with the help of Xilinx ISE 10.1 Simulator. In this case, we used ‘dht’ libraries. Next, we set the FPGA pins and attached them to the SEVEN SEGMENT DISPLAY for display.

I/O Name	I/O Direction	LOC
AN[0]	Output	P23
AN[1]	Output	P24
AN[2]	Output	P26
AN[3]	Output	P27
Clk_i	Input	P52
DISP[0]	Output	P18
DISP[1]	Output	P17
DISP[2]	Output	P15
DISP[3]	Output	P14
DISP[4]	Output	P13
DISP[5]	Output	P12
DISP[6]	Output	P1
reset_i	Input	P76
w1_o	InOut	P82

Table 1. user constraints file

FPGA pins 18,17,15,14,13,12,1 was attached to the D0, D1, D2, D3, D4, D5, D6 pins respectively and pins 23,24,26,27 were attached to the A0, A1, A2, A3 pins respectively on the SEVEN SEGMENT DISPLAY. The ck pin was set to 56. The 'pin Mode' of FPGA pin 82 was set as INPUT/OUTPUT. This is the pin that reads the numeric values from the signal pin of the DHT11 sensor. At least a second delay is required to get reliable readings from the DHT11 sensor. However, we used three (3) seconds delay to ensure that the previous values have been displayed. It is also important to confirm that the temperate and humidity readings are within the acceptable range for the sensor. In this work the humidity range was between 20 - 90 relative humidity, while the temperature ranged between 0 - 50 0 c. Once the read values are within range, it is displayed on the SEVEN SEGMENT DISPLAY screen as seen in Figure shown below.

figure 5. result of relative humidity

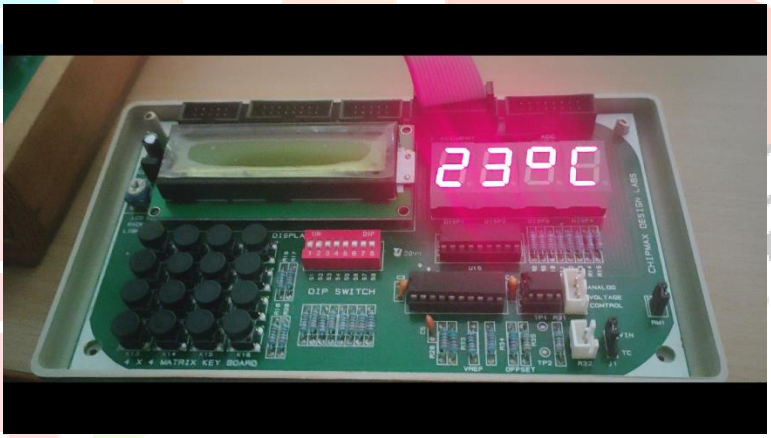

figure 6. result of temperature

In the below figure showed, the circuit connection where dht11 sensor is connected to the FPGA board along with a pullup resistor (5k). The data pin is connected pin 6, vcc to pin 9 and ground to pin 10 of FRC (Functional Redundancy Checking) – 1 of the spartan 3 FPGA board along with that we have also connected the GPIO board which consists the seven segmented display is connected to the FRC (Functional Redundancy Checking) – 5.

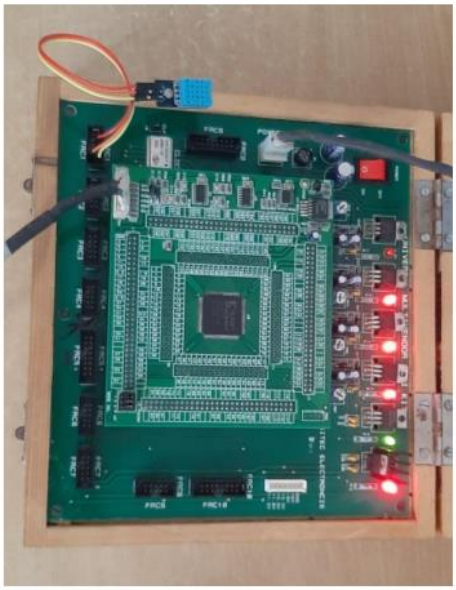

figure 7. circuit connection

We have also tested main rtl code using Xilinx 10.1 software where we have given our own temperature and relative humidity value to show at specific time period is shown in below figure.

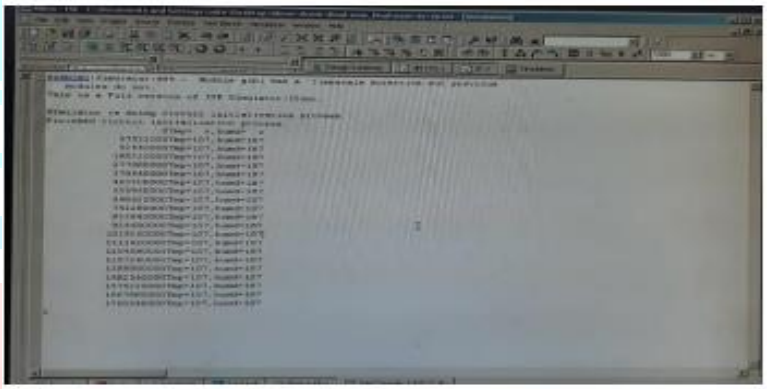

figure 6. testbench result

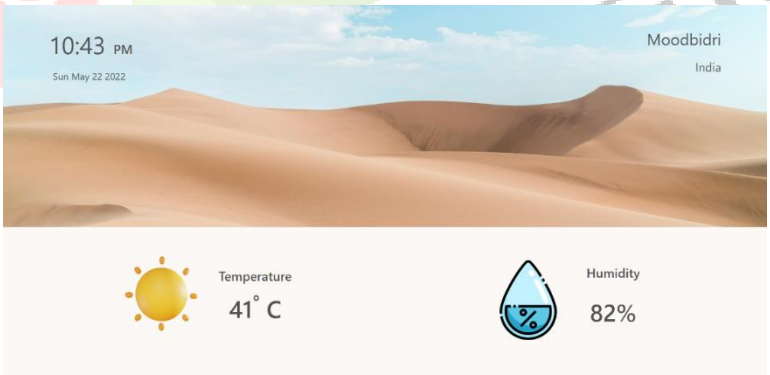

figure 7. web page result

In the figure the web page is shown which displays a temperature and humidity of a room or a place where the data or values can be seen to maintain the place like industry and agriculture

VI. CONCULSION

This weather monitoring system is simple and low-cost which uses sensors, LED and FPGA system to monitor weather conditions in the desired location. Parameters like temperature and humidity l can be monitored by using the DHT11 sensors. With the help of this parameter huge improvement in the production rate of agriculture yield. Temperature will decide the time duration to water the plants. Humidity will decide what type of crop should be produced efficiently. FPGA system is used because it has low cost, less power consumption and system require less program.

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