Design A Nebulizer and Its Implementation on FPGA Using HDL

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Abstract---VLSI systems plays important role among all other system. A nebulizer is a drug delivery device used to administer medication in the form of a mist inhaled into the lungs. The application of spray device to treat respiratory disease has been effective for long time. Asthma and chronic obstructive pulmonary disease are widely prevalent in industries part of the world. The principle of ultrasonic nebulizers is based on the vibrations of a piezoelectric crystal driven by an alternating electrical field. These periodic vibrations are characterized by their frequency, their amplitude, and their intensity, which corresponds to the energy transmitted per surface unit. When the vibration intensity is sufficient, cavitation occurs, and droplets are generated. For a given nebulizer, the vibration frequency of the piezoelectric crystal is fixed, often in the range 1 to 2.5MHzThis is different way to design nebulizer on FPGA spartan3E kit using Xilinx tool using Verilog HDL. We have tried interface ADC device.

Keywords:- FPGA, Spartan3xs1000**,** Analog to Digital Conveter(ADC), Xilinx ,Piezo electric buzzer,Proteus

I. Introduction

Nebulizers are commonly used for delivery of inhaled medications since they transform a liquid medication into a mist that can be comfortably and easily inhaled by a patient. The mist consists of a suspension of many miniscule liquid droplets in air and is created by the nebulizer rapidly, forcibly, and repeatedly disrupting the surface tension of the water and throwing droplets from the bulk liquid surface into the air. The two different types of nebulizers commonly used for inhalation therapy are the jet nebulizer and the ultrasonic nebulizer, each of which have different advantages and disadvantage. Jet nebulizers use a narrow stream of pressurized air to disrupt the surface tension of the bulk liquid in order to aerosolize the liquid medication. The average droplet size formed by jet nebulizers is between 5 and 600, depending on the nozzle. We have built ultrasonic nebulizer which uses a piezoelectric crystal to convert the drug droplets into vapor form which could be delivered to patients. Nebulizers are commonly used for the treatment of cystic fibrosis, asthma , COPD and other respiratory diseases.

Ultrasonic wave nebulizers were invented in 1964 as a new more portable nebulizer. The technology inside an ultrasonic wave nebulizer is to have an electronic oscillator generate a high frequency ultrasonic wave[5], which causes the mechanical vibration of a piezoelectric element. This vibrating element is in contact with a liquid reservoir and its high frequency vibration is sufficient to produce a vapour mist[6] As they create aerosols from ultrasonic vibration instead of using a heavy air compressor, they only have a weight around 170 grams Another advantage is that the ultrasonic vibration is almost silent. Examples of these more modern type of nebulizers are: Omron NE-U17and Beurer Nebulizer IH30.

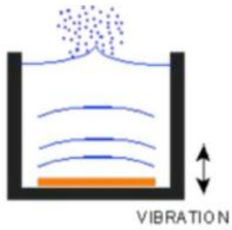


Fig. 1: Ultrasonic Nebulizer

II. Nebulizer Design Flow

The vibration device is basically divided into two modes. In the manual mode, the PWM signals in the output changes according to the variation in potentiometer. Hence in this mode the user could change the frequency according to his/her need. In the automatic mode, there is a timer kept which will monitor the time for which drug is delivered and then after some specific time the drug delivery stops.

A. Manual Mode: As seen in the figure 2 below, the input frequency is obtained from the Analog to Digital converter. As per the digital output the PWM signals will be generated. These PWM signals will vibrate the crystal and the drug will be converted from liquid form into mist.

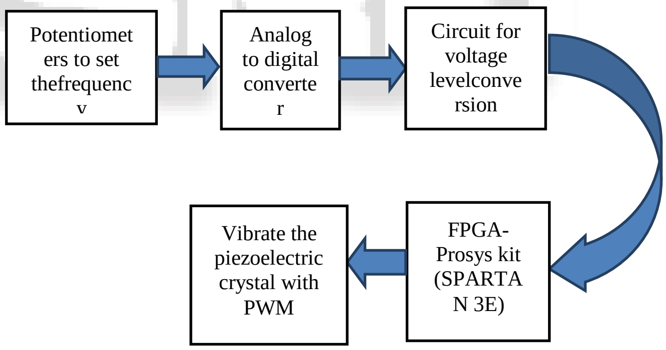


Fig. 2: Block Diagram of the Circuit

The main challenge in the manual mode was to convert voltage levels. The Prosys kit works on 3.3V level and the ADC0804 works at 5V. Hence we need a circuit that can convert 5V to 3.3V and also from 3.3V to 5V. We first thought of using just resistor to drop down the voltage from 5V to 3.3V, but we were advised to use transistors so that the circuit becomes more reliable. Hence we designed a circuit that can be used to convert 5V to 3.3V and vice versa. The circuit is shown in the figure below.

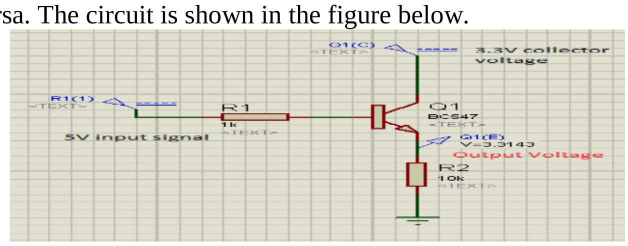


Fig. 3: Circuit for 5V to 3.3V conversion

In implementing this circuit we first used a voltage divider circuit to produce 3.3V but that circuit produced erroneous output. Hence we had to use the diodes to drop down the voltage from 5 to 3.3V. This circuit working is relatively simple.

For the circuit in figure 3, when input 5V is applied to the transistor's base, the transistor turns ON and hence 3.3V are obtained at the emitter terminal before the resistor. When 0V is applied at the base of the transistor then the output will be 0V as ground path will not be provided as transistor is OFF.

For the circuit in figure 4, when the input is 3.3V then the transistor will be turned ON and the collector voltage will be 0V. This is given to the base terminal of another transistor which is OFF and hence the output voltage at that collector terminal is 5V.

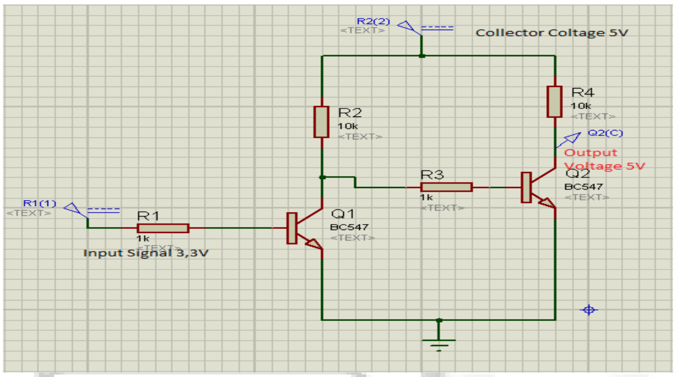


Fig. 4: Circuit for conversion from 3.3V to 5V

B. Sleep Mode: The concept behind this mode is to stop the over dosage of the drugs inhaled by patients. In this mode there is a timer which controls the time for which the drug is delivered to the patients. After a time period the drug delivery will be automatically stopped. The main idea behind this mode is because when a survey was made, results showed that 38% to 40% people did not know for how much time they had to take drug dosage. There working of this mode is given below

III. SOFTWARE DESIGN IMPLEMENTATION

We have worked on Xilinx platform. **Xilinx ISE** (**I**ntegrated **S**oftware **E**nvironment) is a software tool produced by Xilinx for synthesis and analysis of HDL designs, enabling the developer to synthesize ("compile") their designs, perform timing analysis, examine RTL diagrams, simulate a design's reaction to different stimuli, and configure the target device with the programmer.

The flowchart of the manual mode can be given as below. When the input is given to the FPGA through ADC then the PWM signals are generated. The figure below explains how PWM is generated. The working is explained below

- As the 8 bit data received from ADC the FPGA kit starts the operation. The algorithm given below.
- As the process starts FPGA will send WR High to Low signal it signed that the conversion process starts.
- FPGA will continuous check the INTR pin. When pin INTR has 0V then conversion is finished else the conversion is not finished. If conversion is finished then FPGA send high to low signal to RD pin for reading the data.
- FPGA start receiving the input 8 bit data. It checks each data and according to that it will assign the value of value of n is our actual output. The value of n decides the frequency that crystal will have to vibrate.
- Here n is nothing but the variable float number which is useful for generation for PWM. This value of n is used for fine tuning.

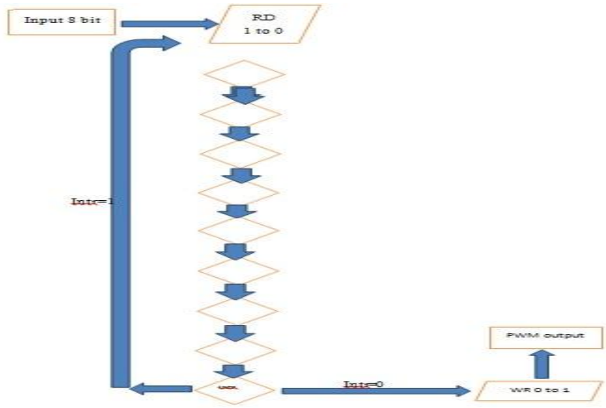
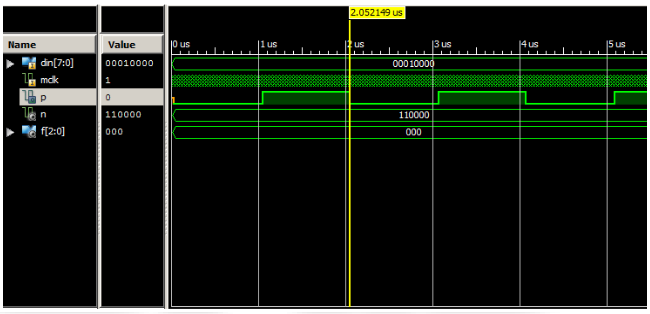


Fig. 4: Software Design Flow

A. Simulation Result:



IV. HARDWARE IMPLEMENTATION

A. Main Components: In this paper the main hardware components used are given below.

- SPARTAN XCS1000
- ADC 0804
- IC 7805
- BC 547
- Piezoelectric Buzzer

The main part in the hardware was to convert 5V to 3.3V and from 3.3V to 5V. The circuits for the conversion are explained in the above chapter. We used that circuit to create the prototype of the Nebulizer. The ISIS file for the prototype is as shown below in figure 5.

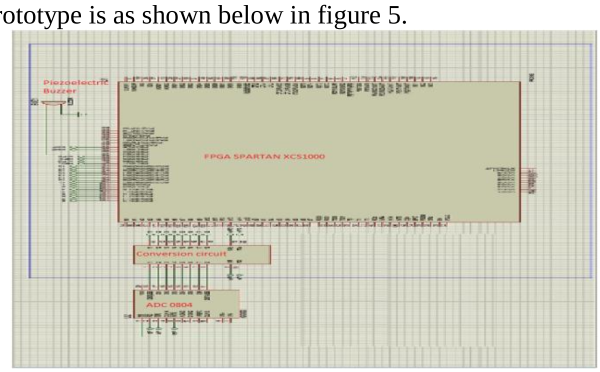


Fig. 5: Basic Circuit in ISIS

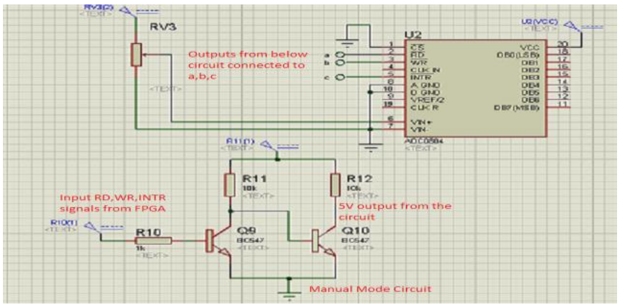


Fig. 6: Hardware design in ISIS

In the above figure the hardware design of our prototype is shown. Here signals such as read, write and INTR coming from the FPGA are converted to 5V as the ADC works on 5V.

The clock circuit that has been implemented is not shown in the above figure.

Below figure represents our hardware implemented on General Purpose Board (GPB). The explanation of how our hardware works is given below.

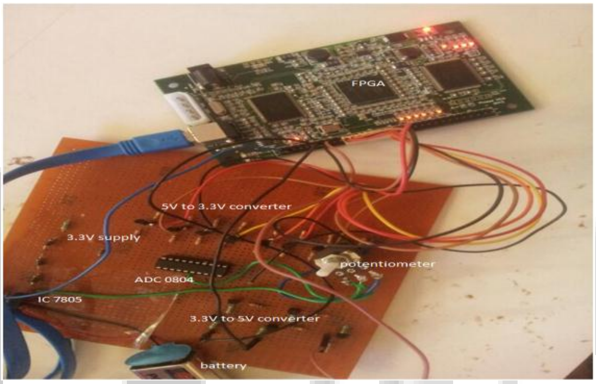


Fig. 7: Hardware Design

In the above figure the IC 7805 is used to get output of 5V from 9V battery. We have used three PN junction diodes to convert 5V to 3.3V as the voltage drop across each PN junction diode is approximately 0.7V, hence we can obtain 3.3V that has to be given to the collector of transistors. The ADC circuit is connected according to the circuit diagram shown in the figure. Hence by making this conversion circuit we could obtain the digital output from the ADC. It has voltage level of 3.3V instead of 5V.

V. CONCLUSION

By doing this project we learned about the medical instrument nebulizer. How it works, when is it needed? , who needs it, etc. The work shown in paper is done on FPGA kit SPARTAN XCS1000 kit and the Prosys kit. It provides a wide input range due to periodic reset of the inputsignal and subsequent digital realignment. Also, drift is reduced to a lineardeviation so signals down to very low frequencies can be recorded.We worked in Globaltech India Pvt Ltd and learnt a lot about how to work in a professional world.

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