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# E-VLSI Lab Using Raspberry PI

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**ABSTRACT**

E-learning has proved to be a very useful technology. Along with e-learning, e-labs are also implemented. There are two types of e-labs, virtual and remote. This paper is an initiative to create an e-lab for remote FPGA using Raspberry Pi. The main component of this project is the Spartan 3E family of FPGA, which will be interfaced with the Raspberry Pi board using Webiopi. A field-programmable gate array (FPGA) is an integrated circuit that can be configured by a user after it has been manufactured. Therefore, it is called as field programmable. Its configuration can be specified using a hardware description language (HDL). It is a highly flexible and efficient circuit. Raspberry Pi is a small size, low cost computer that can be plugged in and operated using a monitor, keyboard and mouse. It uses the Raspbian operating system. In this the Raspberry Pi GPIO pins are controlled by the Webiopi. The outputs and the lab environment can be viewed through the webcam connected to the Raspberry Pi. It is also advantageous as experiments can be performed anytime, anywhere.

***Keywords:*** FPGA, Raspberry Pi, Webiopi

## 1. INTRODUCTION

Today, the use of remote labs [1] in the field of electronics is increasing at a rapid rate. Virtual labs are usually used to provide software simulations of various physical processes, while the remote labs provide users an environment to remotely work on real experiments, so as to make testing its performance more realistic. In the field of VLSI, checking the validity of real data is important so as to assess the efficiency of the design. But, doing this for every individual design will make it more difficult and expensive while handling complex FPGA kits. To overcome this issue, we make use of the remote VLSI lab that uses the Xilinx software [3] [4], Spartan 3E FPGA (XC3S250E) [7], Raspberry Pi and Webiopi. Xilinx is a very easy to learn powerful language which is used as a standard tool for VLSI design. Xilinx provides a friendly environment to interact with the remote lab. We are using the Spartan 3E FPGA (XC3S250E) due to its high flexibility and efficiency. The FPGA can be reconfigured easily according to the user's needs which are not possible while using other circuits. Raspberry Pi is a cost efficient credit card sized board which can be used to select the inputs and outputs of the FPGA. This selection is controlled by the user through Webiopi free web interface.

## 2. FIELD PROGRAMMABLE GATE ARRAY (FPGA)

Field Programmable Gate Arrays (FPGAs) are semiconductor devices that involve a matrix of configurable logic blocks (CLBs) connected via programmable interconnects [2]. It is possible to reprogram the FPGA according to the desired application or the functionality it must perform after its manufacturing. Thus an FPGA differs from an Application Specific Integrated Circuit (ASIC) as ASICs are designed only for a specific application or design. We have two types of FPGA, the One Time Programmable (OTP) FPGA and the SRAM based FPGA. In OTP the FPGA can be configured only once while in the SRAM based we can configure the FPGA as the design evolves. The SRAM based FPGA is the more dominant type. Contemporary field-programmable gate arrays (FPGAs) have large resources of logic gates and RAM blocks to implement

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complex digital computations. Some FPGAs have analog features in addition to digital functions. The ability to update the functionality after shipping, partial re-configuration of a portion of the design and the low non-recurring engineering costs relative to an ASIC design , offer advantages for many applications. Taking advantage of hardware parallelism, FPGAs exceed the computing power of digital signal processors (DSPs) by breaking the paradigm of sequential execution and accomplishing more per clock cycle.When compared to an Application Specific Intergrated Circuit (ASIC), the Field Programmable Gate Array (FPGA) has better performance, Time to Market, Cost, Reliability, and Long-term maintenance The adoption of FPGA technology continues to increase for higher-level tools to deliver the benefits of reprogrammable silicon to engineers and scientists at all levels of expertise.In this paper, the programs/algorithms are loaded on the FPGA whose inputs and outputs are controlled by the user using Raspberry Pi.

## 3. ROLE OF RASPBERRY PI

The Raspberry Pi [6] is low cost credit card sized boards which can be connected with monitor and keyboard to be used as computer. In our project Raspberry Pi is used to provide interface [12] between the user and the computer and its GPIO pins are used to control the inputs and outputs which are given by the user through the internet via Webiopi free web interface. These pins are also used to select the program to be executed which has been stored in the data flash of the FPGA.

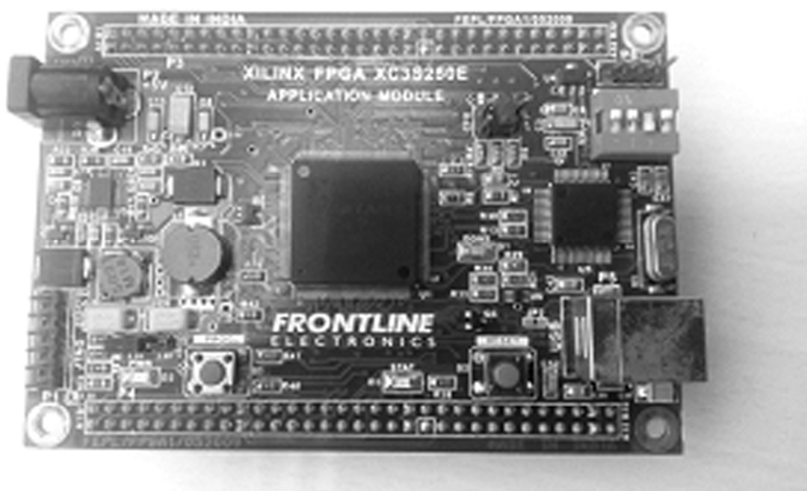


**Figure 1: Field Programmable Gate Array (FPGA) Kit (XC3S250E)**

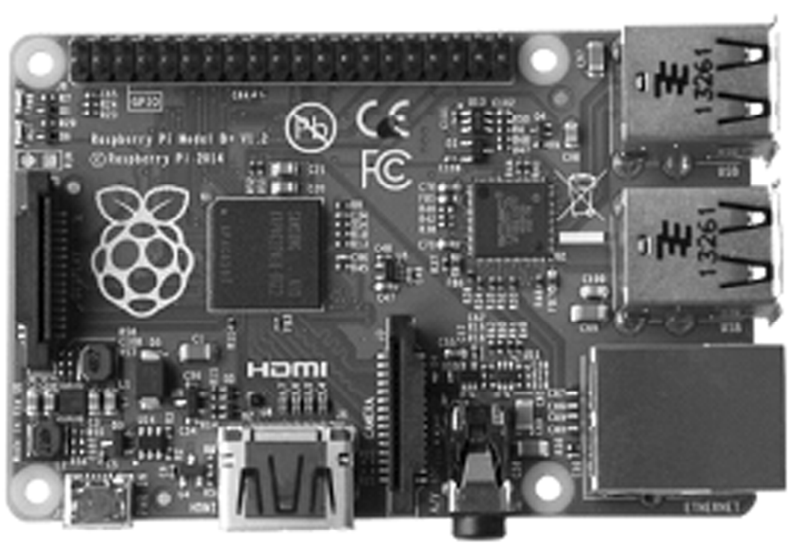


**Figure 2: Raspberry Pi Board**

## 4. WEBIOPI

This is a free web interface which is used to interface the user with the Raspberry Pi, so that the user can select the GPIO pins in the Raspberry Pi via internet and change the input and output for a particular program loaded in the data flash of the FPGA. The Webiopi [5] which we are going to use is of higher version. Initially few steps are to be followed to load the software [11] on to the Raspberry Pi and then later by selecting the GPIO header we get the outline of it which can be controlled by the user through the internet.

## 5. IMPLEMENTATION

The user initially connects to the given webpage through a common browser in which all the tools like Xilinx, Webiopi etc. are all integrated. Users using the E-lab [8] [9] for the first time have to register with the website thus creating an account for them. Once they log in to their accounts they select the Xilinx ISE platform and enter the program they wish to execute. ISE design tool “impact” is used for implementation. Once the program is implemented it is mounted on to the data flash of the FPGA kit by the user from the remote desktop. Thus the configuration of FPGA is done successfully.

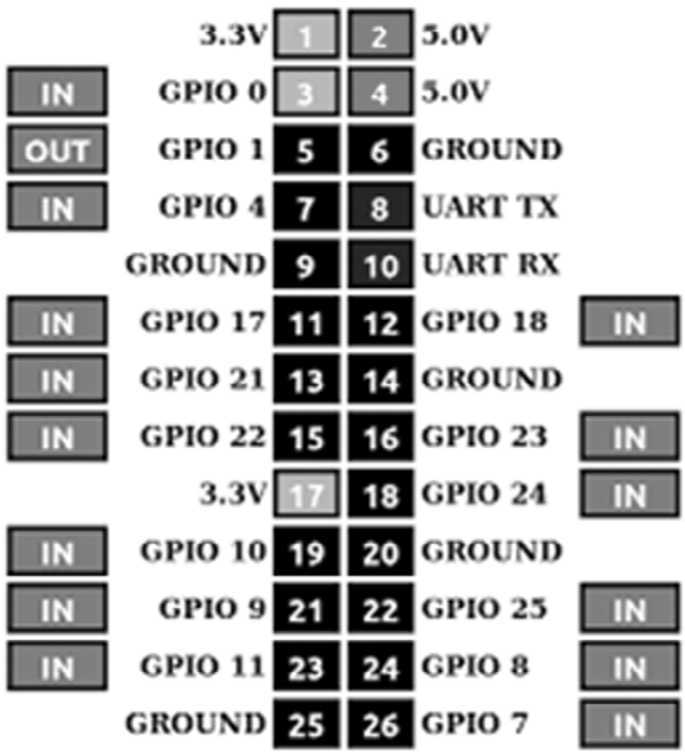


**Figure 3: GPIO Header of Raspberry Pi**

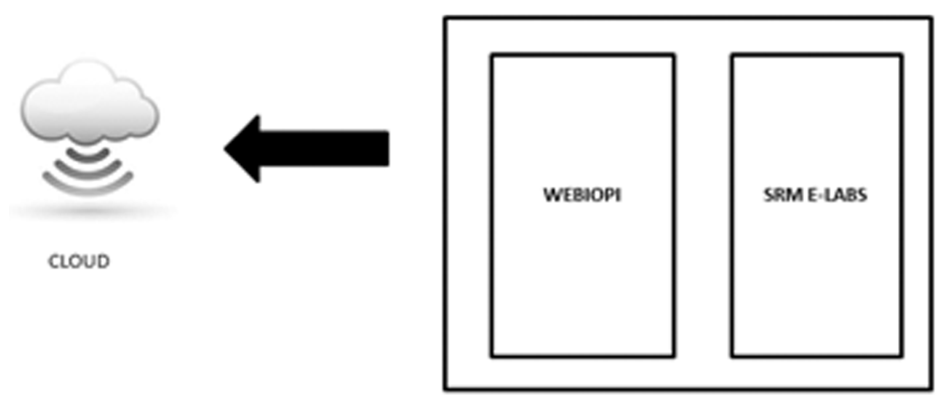


**Figure 4: Transmitter Block showing the control given from the user to the cloud through Webiopi and SRM elabs.**

Webiopi software is used in order to interface the inputs and outputs of the FPGA kit with the PC.To connect the PC of the user with the FPGA and Raspberry Pi board is used. The webpage contains the GPIO header where the inputs have to be given. These inputs are transferred to the FPGA kit through the Raspberry Pi board. The corresponding output from the FPGA is sent to the Raspberry Pi which is then viewed on the

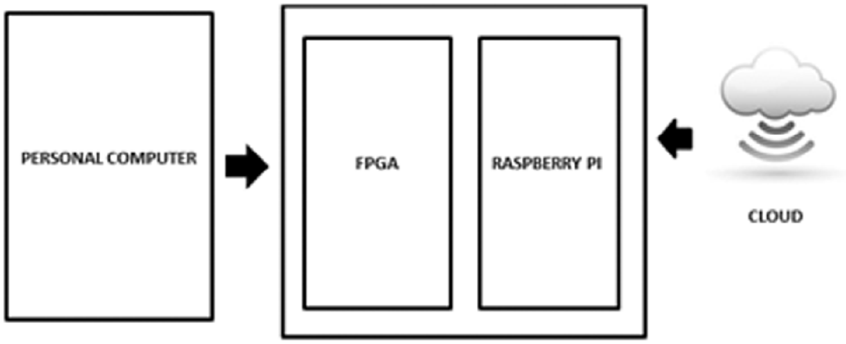


**Figure 5: Receiver Block showing the inputs and outputs of the FPGA controlled by the Raspberry Pi through the cloud.**

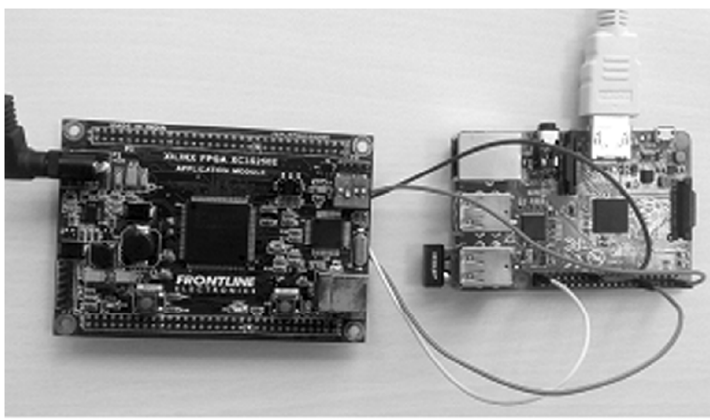


**Figure 6: Basic Setup**


**Figure 7: Login Environment**

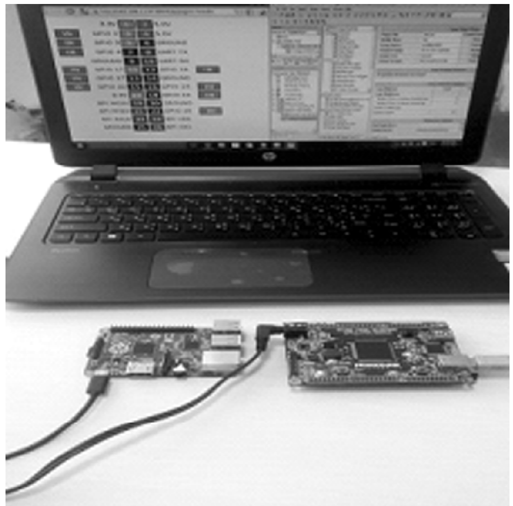

Figure 8: Remote Lab Setup

PC screen. A webcam is also interfaced with the Raspberry Pi to have a clear view of the entire setup and the output.

## 6. STEPS TO BE FOLLOWED

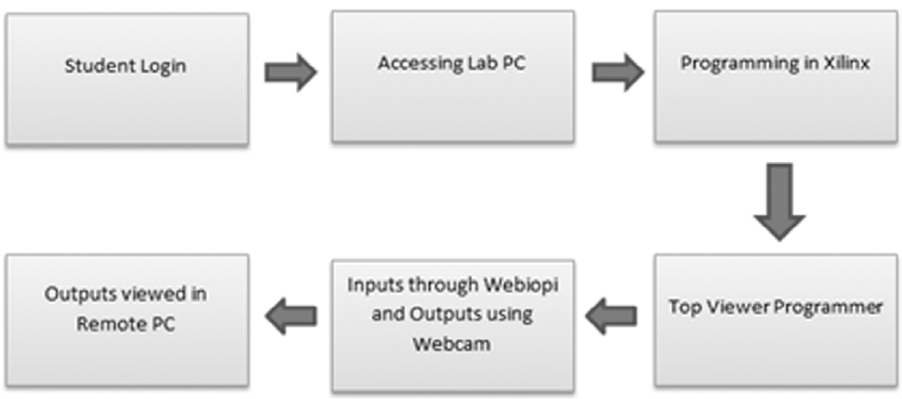


Figure 9: Flow Diagram showing the steps that needs to be followed

## 7. CONCLUSION

In this paper, we present a remote lab for implementing HDL designs in FPGA kits. A user can implement the desired design using Xilinx ISE Design Suite via the internet. The user can be provided with an input-output interface with video streaming using a webcam. Complex circuit designs can be tested, analyzed and implemented using this cost effective and efficient setup. Using this setup we can experiment various concepts remotely. In future, this setup can be enriched with additional features for user interface.

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