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Project Phase II Report

Remote Digital Lab for Students

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FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS

M.TECH IN EEE

FACULTY OF ENGINEERING

DEPARTMENT OF ELECTRICAL AND ELECTRONICS

MASTER OF TECHNOLOGY

CERTIFICATE

This is to certify that the Dissertation entitled

“Remote Digital Lab for Students”

Is a Bonafide work carried out by

ASHOK M (PES1PG19EE004)

In partial fulfilment for the completion of the course work in the Program of Study M.Tech inElectrical and Electronics Engineering under rules and regulations of PES University, Bengaluru during the period January 2021 – May 2021. It is certified that all corrections/suggestions indicated for internal assessment have been incorporated in the report.

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1.

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DECLARATION

I Ashok M, hereby declare that the project entitled, **"Remote Digital Lab for Students"**, is an original work done by me under the guidance of **Dr.Venkatarangan M J**, Professor, Dept. of EEE, and is being submitted in fulfilment of the requirements for completion of the course work in the Program of Study M.Tech in Electricaland Electronics Engineering.

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ACKNOWLEDGMENT

I extend my deep sense of gratitude and sincere thanks to our chairman **Dr. M.R.Doreswamy** (Founder, Chancellor –PES University), **Prof. Jawahar Doreswamy,** Pro-Chancellor of PES University and **Dr. J Surya Prasad**, the Vice Chancellor of PES University for giving us an opportunity to be a student ofthis reputed institution.

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ABSTRACT

Today's embedded system designer has little assistance in performing system design tasks. Widely accepted methodology or tool is available to help the designer create a functional specification and map it to a system-level architecture. A hierarchical methodology, we first precisely specify the system's functionality, explore numerous system-level implementations with the aid of tools, and automatically generate a refined description, which represents any implementation decisions. Digital electronics experiments over the internet can be accessed by the students. The setup allow students in situation where traditional laboratory equipment is either unavailable or in any practice period. The usage of remote e-Learning platform enables engineering students to achieve practical knowledge and skill of emulating digital circuits. It also provides better understanding of analysis of the circuits.

The system will comprise of ESP8266 microcontroller that has an inbuilt Wi-Fi and good number GPIO can be obtained by interfacing PCF8564 with it. The system will have the capability to execute the digital experiments via Wi-Fi. Wi-Fi being the highest priority to access the system remotely. The system will have the capability to work on power source, or battery backup.

The Virtual systems are partially available but need to take the steps towards Hardware implementation. The steps of adding Remote accessing functionality, Wi-Fi module to the system, writing code verifying various test cases, building digital circuits for the system, and mechanical casing for the system, and handing over this towards productization is the steps that is to be taken in this project.

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CHAPTER 1

1.1 INTRODUCTION

MOTIVATION / PROBLEM STATEMENT

As part of curriculum, UG students in ECE and EEE disciplines will need to work on Digital trainer kits for their digital electronics lab course. Many times the students would like to spend more time for different reasons in the execution of the experiments:
1) Allocated time is not enough to complete experiments, could not understand all the concepts of experiment, some wrong doings on few experiments which delays later experiments
2) Keen to explore further and get more insights by trying out different circuits
3) Would like to review and repeat the experiments as the exam approaches
With the current situation today, there are no alternative other than students being physically available in the lab. There is a need to address this issue which is even more important for Pandemic like situations.

- The problem statement is addressing the issue of remotely working on digital trainer kit without physically being in the lab.
- Solutions are available in market in form of circuit simulators and other kind of virtual labs which work quite well and are used heavily circuit designer to test the designs prior to fabrication.
- The attempt in this project is not to use simulators but enable students to use the actual hardware like they are in the lab physically.
- Digital electronics experiments over the internet can be accessed by the students. The setup allow students in situation where traditional laboratory equipment is either unavailable or in any practice period.

1.2 OBJECTIVE

- Development of a Digital trainer hardware platform that can be accessed remotely
- Development of friendly user interface which is close to how they would have handled the kit in the lab.

The deliverable of project includes:

- Phase 1: Digital IC kit side hardware development and tests

  1) Design of hardware comprising of digital ICs inline the digital trainer kit and hooks
  for controls from external boards

  2) Fabrication of hardware to check the functionality manually and with MCU board

  3) Basic Software on MCU board to check functionality of hardware.
- Phase 2:

  4) Delivery of software for an embedded board that receives commands via internet and acts like IoT device on one side and controls the hardware board on other side

  5) PC application for students which can be used to select connections of different ICs to perform digital electronics experiments.

  6) Demonstration of 5 experiments that are available as part of curriculum today

CHAPTER 2

2.1 LITERATURE REVIEW

Pruthvi, P et al, this paper, a setup is proposed to perform modern digital lab experiments remotely in a distance learning vi rtual environment. The National Educational Remote Instruments were utilized in this setup. Students can perform tedious experiments here [2]. In this paper they are looking for data acquisition concept where we are just controlling digital I/O’s and not going to utilize higher end NI systems.

Manfred Leisenberg et al, this paper introduces a new technique that allows the student /instructor to bring the construction of hardware and the lab experiments into the Digital Lab environment through the Internet without being present near the actual hardware. A cost-effective way is offered to opening a Laboratory for 24 hours for students to access the Lab experiments.
For the implementation they have used separate wi-fi module to the Arduino Uno, where we are implementing the concept with the wi-fi inbuilt controller i.e. ESP8266 [5].

Abu-aisheh Akram A et al, this paper demonstrates the design and functioning of a remote digital design system of low-power for explaining the hypothesis and the design of low-power digital circuit [6].

Oballe-Peinado et al, this paper deals with the setup designed for FPGA concept. But we are looking for the digital electronics circuit laboratory, concepts of accessing the lab is similar but the functionality of lab varies [4].

CHAPTER 3

3.1 ARCHITECTURE SETUP OPTIONS

OPTION 1:

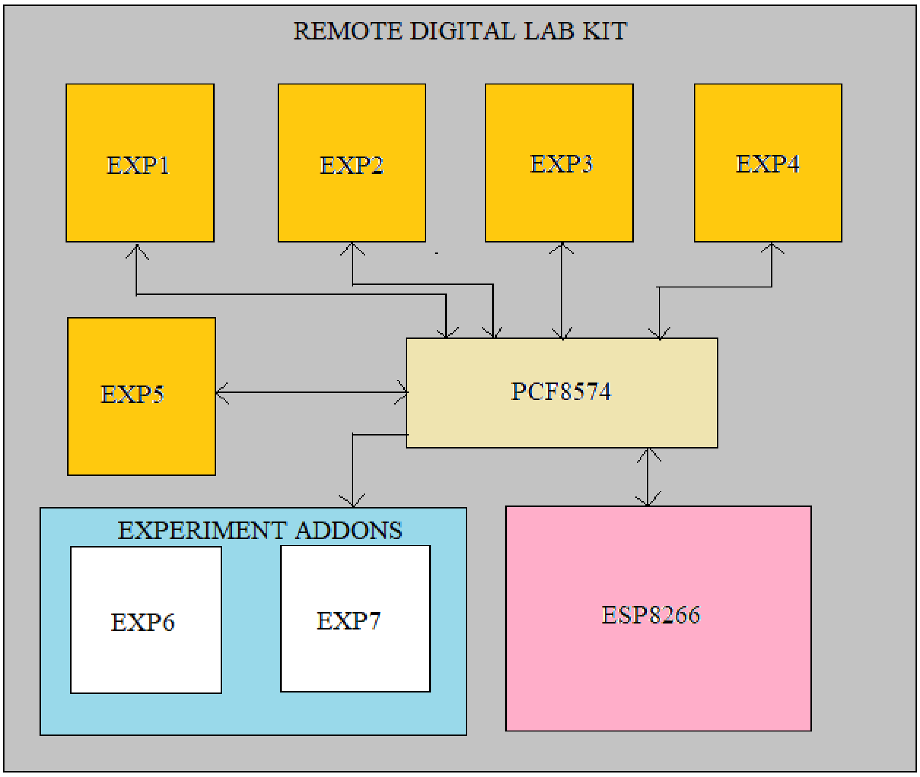

Fig.1 Single Master Multiple Daughter Boards Kit

The Remote Digital Lab Kit consists of ESP8266 a master controller, I/O expander PCF8574 and 5 daughter boards consists of digital IC's required for respective experiments considered. Addons are the future implementation like any extra experiments need to implement in the kit, there is a provision for that work.

Pros:

- Cost effective
- Daughter boards can be maintained easily.
- Addon of experiments can be implemented easily for future work.
- Power Supply rating need not be much.

Cons:

- Only one can use at a time.
- More no of kits need to be purchased to the lab.

OPTION 2:

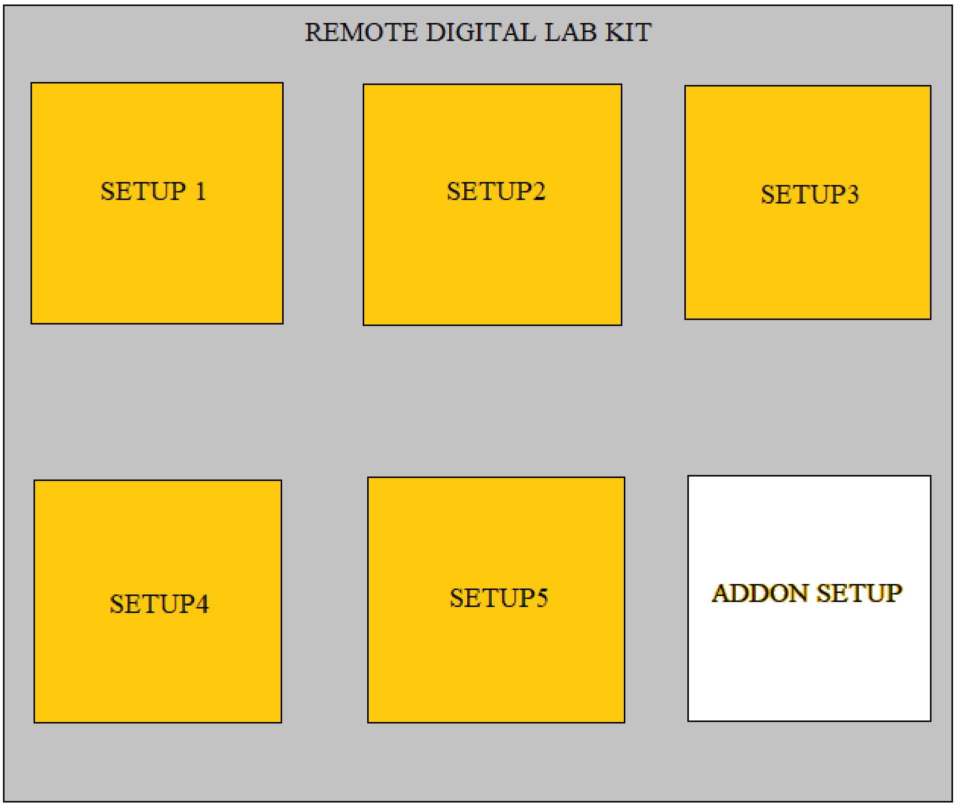

Fig.2 Dedicated Micro controller setup

This Kit compromises with 5 Setups. Each setup consists of dedicated microcontroller talking to its peripheral hardware. Addon can be used for future work where there is a requirement of addition of experiments need to be performed.

Pros:

- Multiple users can access the kit at a time, but one can conduct one experiment at a time.
- Addon of experiments can be implemented easily for future work.
- Replacement of the individual setup can be done easily.
- All setups can be accessed in one shot.

Cons:

- More expensive when compared to option 1.
- No of microcontroller increases.
- Maintenance place a major role.
- Power supply rating should be considered.

OPTION 3:

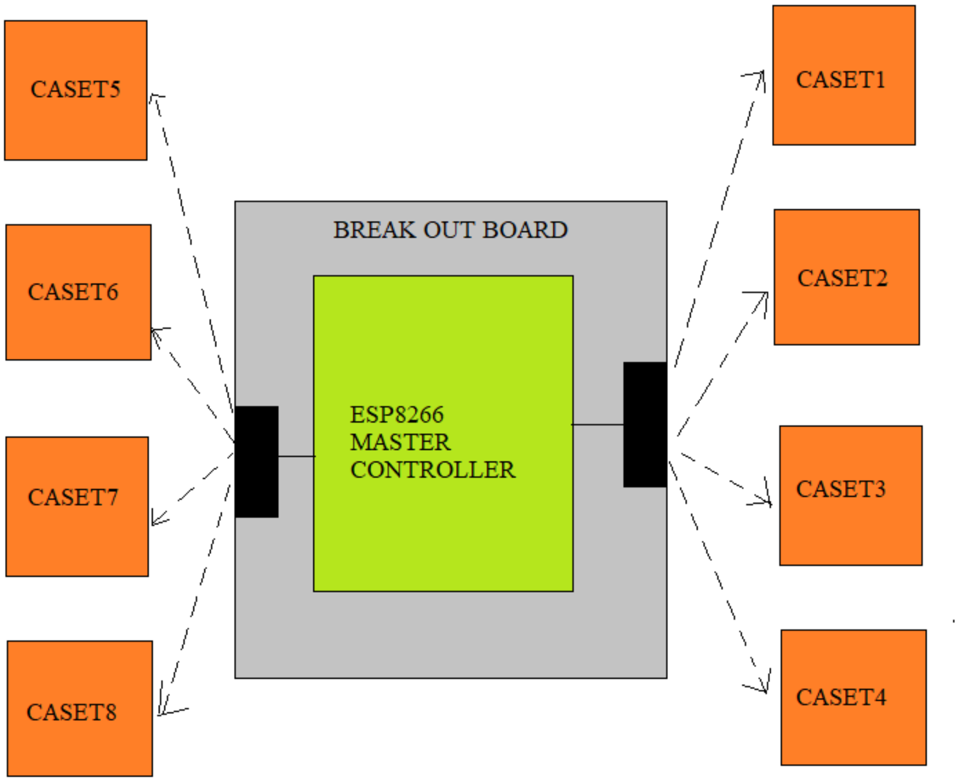

Fig.3 Plug and play kind of lab setup

This design compromises some of the drawbacks from the previous options. Here There is a fixed single Master micro controller for any set of experiment, caset are similar daughter boards. These caset can be detachable. It is a plug and play kind of kit.

Pros:

- Cost effective
- Caset can be maintained easily.
- Addon of experiments can be implemented easily for future work.
- Power Supply rating need not be much.

Cons:

- Only one can use at a time.
- Physical presence of lab technician is required to change the caset.

Looking into the options available for the design we finalised with option one because it is cost effective for production and consumption of power is less. Also the maintenance is not much complex.

CHAPTER 4

4.1 BLOCK DIAGRAM

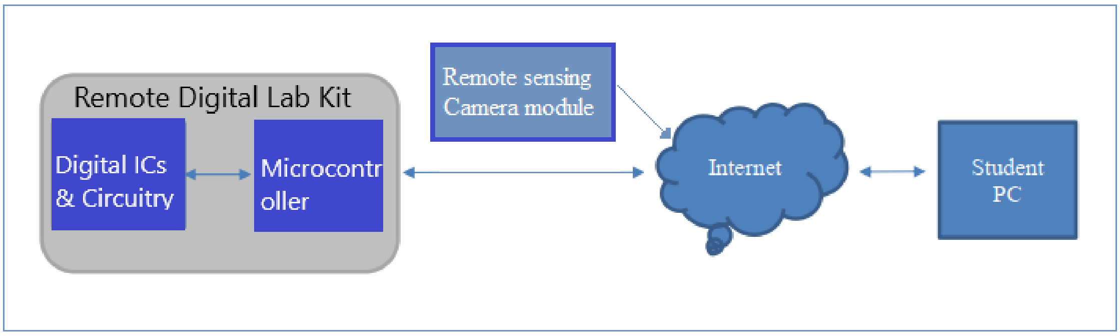

Fig.4 Block diagram_1

4.2 HARDWARE ARCHITECTURE / DESIGN DETAILS

Hardware Architecture

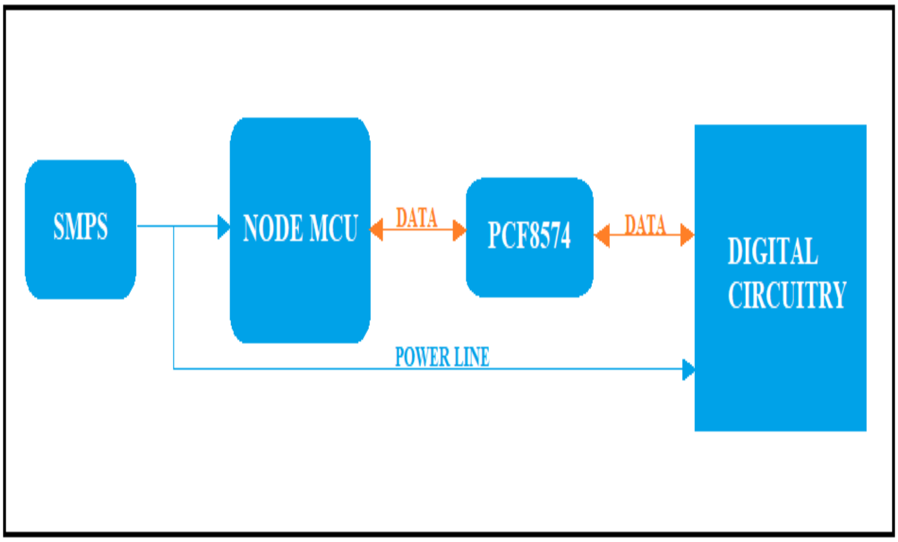

Fig.5 Hardware architecture of the system

Above figure Fig.5 gives a overview of the Hardware architecture of the system. The system is powered up by SMPS (5V 2A). The blue line indicates the power line distributed all over the system. Orange line indicates the data line. The Master controller i.e. NodeMCU controls the whole operation of the system. The Circuits installed in the system talks to the user through the master. The Master in turn talks to the user via Internet.

4.3 EXPERIMENT HARDWARE CONNECTION

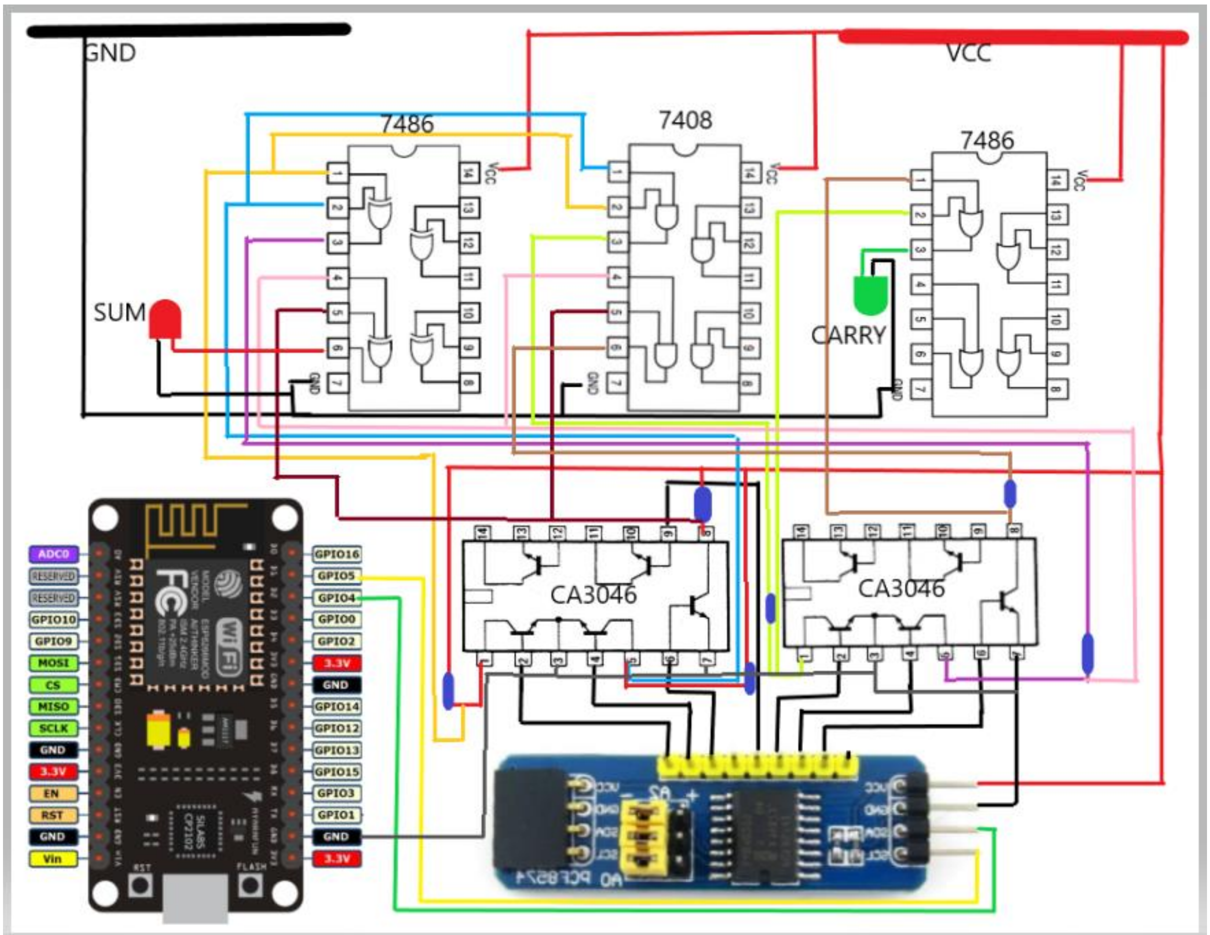

Fig.6 Full Adder Hardware Architecture

In this Remote Digital Lab Kit ESP8266 is the main microcontroller which has inbuilt WiFi. The PCF8574 is interfaced to microcontroller through I2C interface, so that this addon will remove the issue of lagging of digital I/O pins used for switching in Microcontroller. Experiment will talk to Microcontroller via PCF8574. An array NPN transistor i.e. CA3046 ICs are used for switching the logics between gates. User can switch the circuit by connecting the terminals of the ICs used for the experiment needed to be performed. Respective ICs are used to the experiment and are connected to Microcontroller via switches. The outputs are indicated on Sum and carry indicators.

In the similar manner rest 4 experiments considered in the system has the Hardware design.

4.4 HARDWARE INTERFACED TO NODEMCU

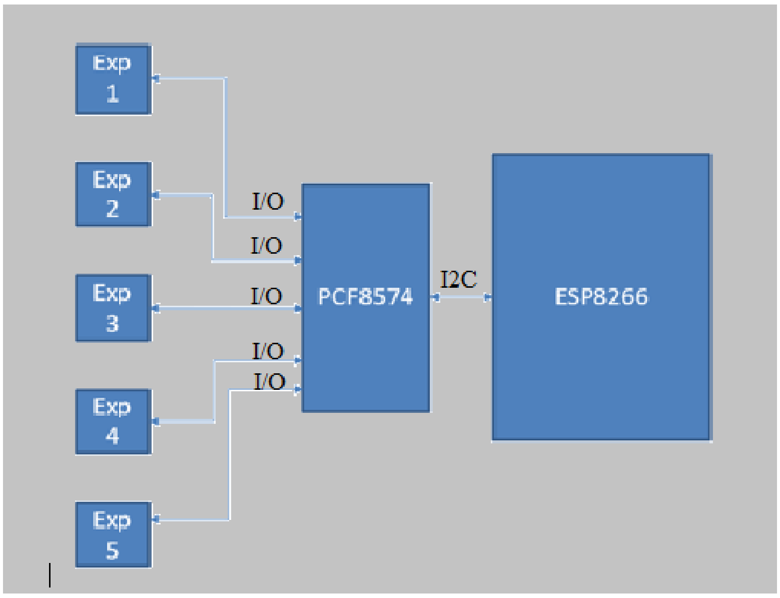

Fig.7 Hardware Interface to NodeMCU via PCF8574 I/O extender

This Fig.7 gives overview of the Hardware talking each other. It also contains the ESP8266 controller that is used to connect the user internet via Wi-Fi interface and the hardware setup in interfaced to it. The user interface can be controlled through the switches i.e. A page designed by the developer with required IO options. The remote accessible device is connected to internet 24/7 so that student can access the setup at any period. A camera setup is considered to get the real time feel. Students were asked to provide inputs of the respective experiments they are going to conduct. Once they are done with the circuitry input in the user interface page. The inputs will be fed to the Remote accessible device and it perform the required experiment and will provide the output in the user interface page. The data can be given through the user interface that is accessed to the kit through the cloud server and experiment is completed .we can observe the result through the user interface.

4.5 COMPONENTS USED AND ITS FUNCTIONALITY

1) NodeMCU Wi-Fi module ESP8266:

NodeMCU is based on Lua firmware. It is a specially designed development board targeted for IoT based Applications. A firmware runs on the ESP8266 Wi-Fi SoC is from Espressif Systems. ESP-12 module-based hardware is designed for the board. NodeMCU has RAM of 128MB and to store data and programs 4MB of Flash memory it has. It has a high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features which makes it ideal for IoT projects. To power NodeMCU VIN pin (External Supply Pin) and Micro USB jack can be used. It supports I2C, UART, and SPI interface. The ESP8266 is integrated with 802.11b/g/n HT40 Wi-Fi transceiver. It can set up a network of its own. It can allow other devices to connect directly to it. This makes the ESP8266 NodeMCU more advanced and versatile.

2) PCF8574:

The input/output (I/O) expander of 8-bit for the I2C i.e. two-line bidirectional bus is designed for 2.5-V to 6-V VCC operation. The PCF8574 provide I/O expansion which general purpose are used for most microcontroller families by I2C interface. The device I/O are bidirectional. Without the use of a data-direction control signal each can be used as an input or output. At power on, the I/Os are high.

3) CA3046:

The CA3046 IC has silicon NPN transistors on a monolithic substrate. Five transistors are included in one IC. Two NPN transistors form a differentially connected pair by connecting themselves internally. The transistors of the CA3046 are suited to the applications of low power systems in the DC. In conventional circuits they may be used as discrete transistors.

4) IC7404:

The SN7404 IC has six inverter gates which are independent. Each gate consists of one input and one output. The primary functionality of 7404 is inverting. Implementation of logical negation can be performed by 7404. Output of the inverter is a voltage which represents the opposite logic-level to input. If the loaded input is high then the output represents low and vice versa.

5) IC7408:

The IC **7408** contains independent four 2-input AND gates. Each gate performs logic AND function. Due to reduced switching delays, IC could be used for high speed AND operation. The maximum supply voltage to the IC can be given upto 7 VDC.

6) IC7432:

IC 7432 consists of OR gates which are four in numbers. Each gate has two inputs and one output. The ICs are made by CMOS, TTL technology. The power supply to the IC is from 4.5V DC to 5.25V DC. If the voltage of the signal is above 2V, IC will consider it as high signal and low if the voltage of the signal is below 0.8V.

7) IC7486:

74HC86 is 2-Input EXOR Gate IC. It is an advanced high speed 2−input Exclusive−OR gate. This circuit constitute of three stages, containing a buffer output which bring forth high noise immunity. Up to 7V of input can be tolerated, allowing interface of 5V systems to 3V systems.

8) IC7485:

The 74HC85 is silicon gate CMOS devices with low power Schottky TTL (LSTTL). The comparison of two 4-bit binary, BCD or other monotonic codes is performed by this IC. For comparison of words more than 4-bits, units can be cascaded by connecting outputs to corresponding inputs of the significant comparator.

9) SMPS:

A switched-mode power supply, an electronic circuit which converts power through switching devices. This can be switched on and off at high frequencies. Storage components like capacitors or inductors are used for power supply while switching device is in its non-conducting state.

Due to the high efficiency of switching power supplies, these are extensively used in a various electronic equipment, such as computers and other sensitive equipment which requiring stable and power supply which is efficient. Switched-mode power supplies are used to power the equipment such as battery-operated devices, computers, sensitive electronics and other equipment requiring high efficiency.

10) AC input:

Here we AC input of 230V which is further converted to DC using SMPS to a suitable voltage to power on the device.

CHAPTER 5

5.1 EXPERIMENT INCLUDED

Experiment1: Full Adder/ Subtractor

Full adder is the circuit where two outputs are produced by adding three inputs A and B are the first two inputs carry in CIN is the third input. C-OUT output is the carry output and SUM is normal output which is nominated as S.

A full adder logic takes all eight inputs together and it creates a byte-wide adder. Carry bit is cascaded from one adder to another.

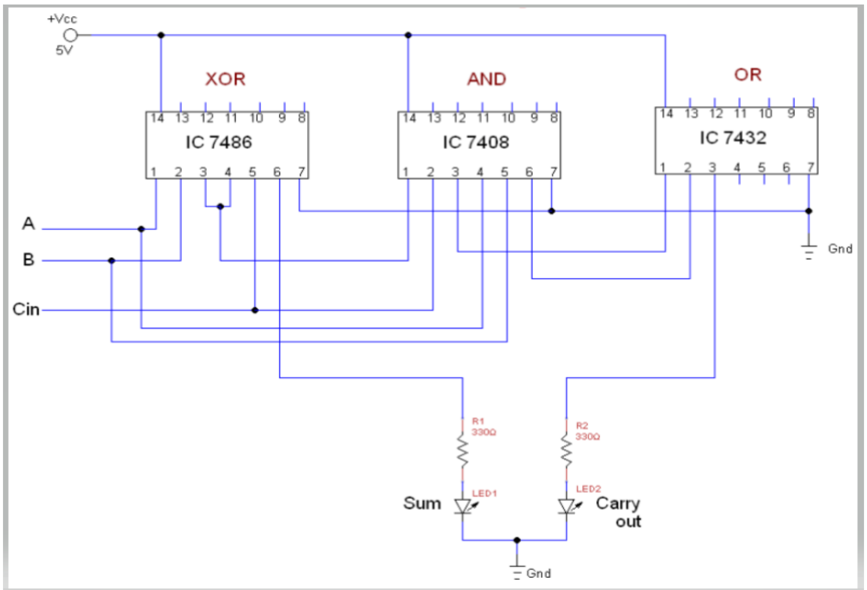

Fig.8 Full Adder circuit.

Inputs			Outputs	
A	B	C_{in}	Sum	Carry
0	0	0	0	0
0	0	1	1	0
0	1	0	1	0
0	1	1	0	1
1	0	0	1	0
1	0	1	0	1
1	1	0	0	1
1	1	1	1	1

Table.1 Full Adder Truth Table.

A full subtractor subtracts two bits. It is a combinational circuit one bit is minuend and other is subtrahend. This consider borrow of the previous adjacent lower minuend bit. It has two outputs and three inputs. In the below circuit A is minuend, B is subtrahend and Bin is previous borrow, respectively. The D and Bout are the two outputs represents the difference and output borrow.

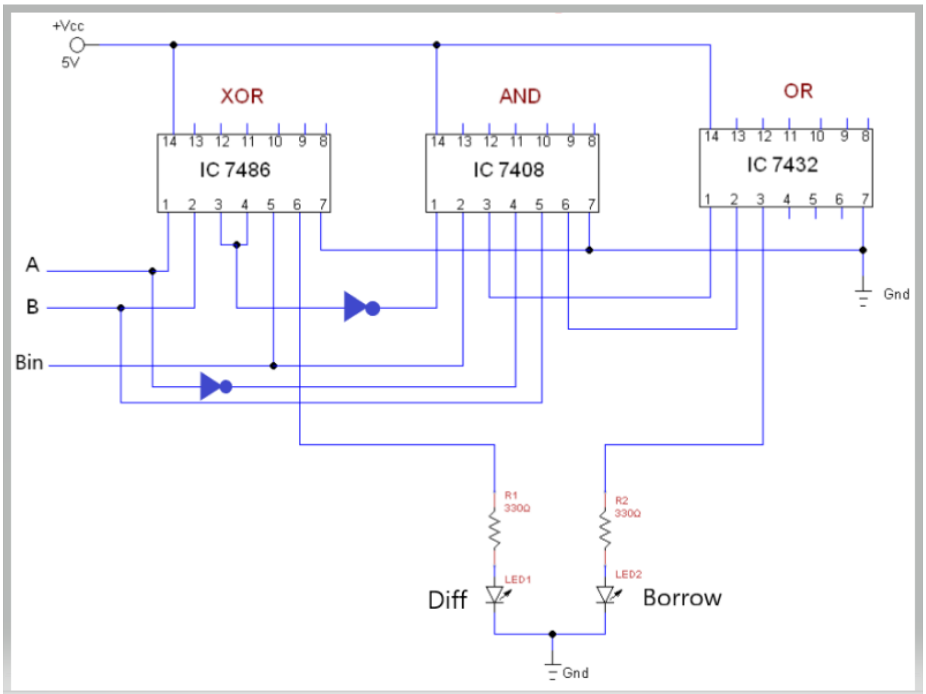

Fig.9 Full Subtractor circuit.

Inputs			Outputs	
A	**B**	**Borrow$_{in}$**	**Diff**	**Borrow**
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

Table.2 Full Subtractor Truth Table

Experiment2: Half Adder/Subtractor

Half adder is a combinational circuit where two bits are added. The output produced is sum and carry. Here the inputs are A and B, S is the sum which is the X-OR of A and B. The carry C is the AND of A and B. By using XOR gate and AND gate one can construct the half adder easily.

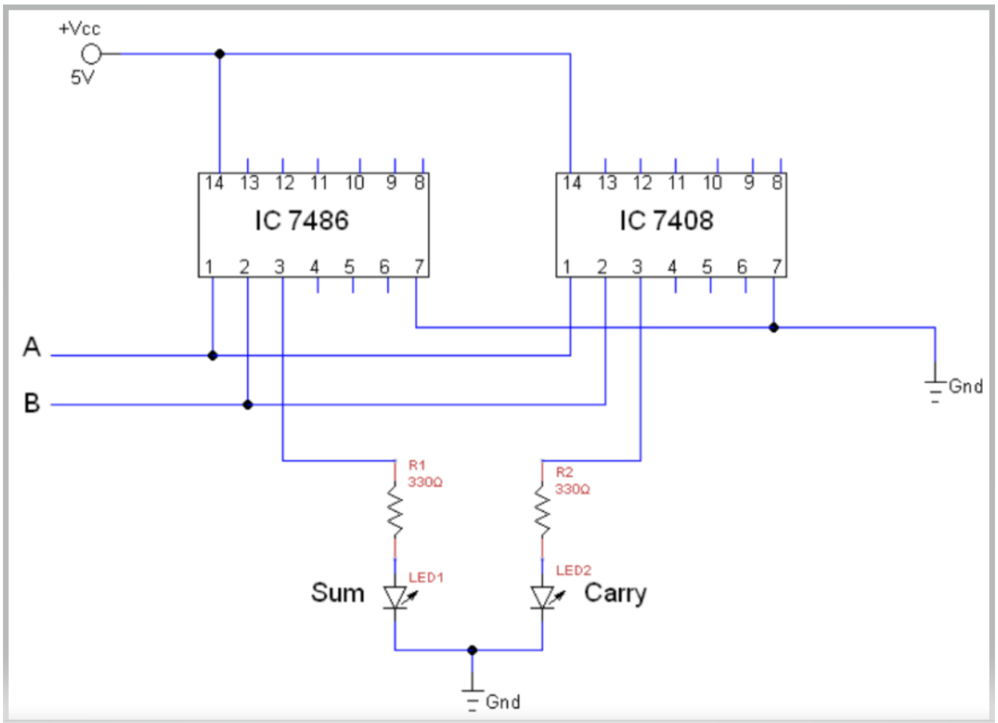

Fig.10 Half Adder circuit.

A	B	SUM	CARRY
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

Table.3 Half Adder Truth table.

Half Subtractor is a combinational circuit whose inputs are A and B. Difference and borrow are the two outputs. In the subtraction A-B, A is called a Minuend bit and B is called a Subtrahend bit.

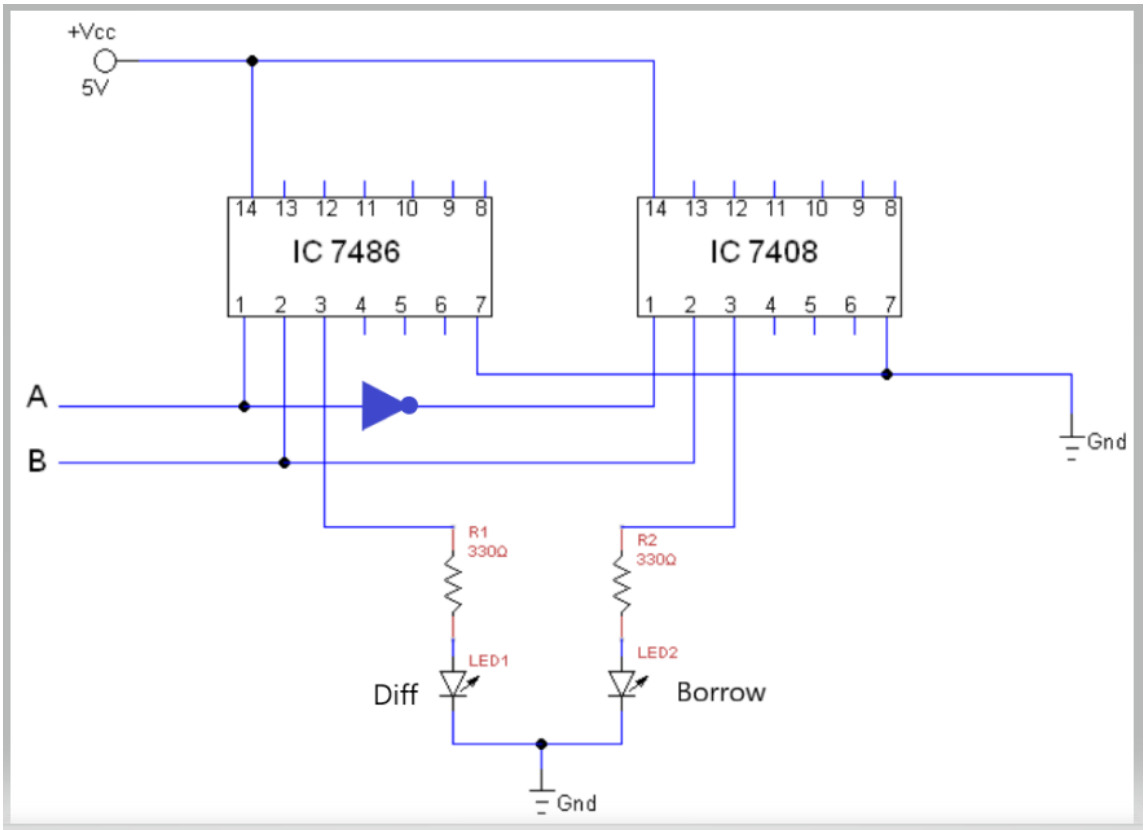

Fig.11 Half Subtractor circuit.

A	B	Diff	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

Table.4 Half Subtractor Truth table

Experiment 4: 4:1 Multiplexer Using Gates

The Multiplexers is a logic circuit which selects single output out of several inputs. The select lines are used to control the inputs. A set of m-select lines are required to select the one output from n-input. 2m=n is the relationship given between n number of input lines and the select lines.

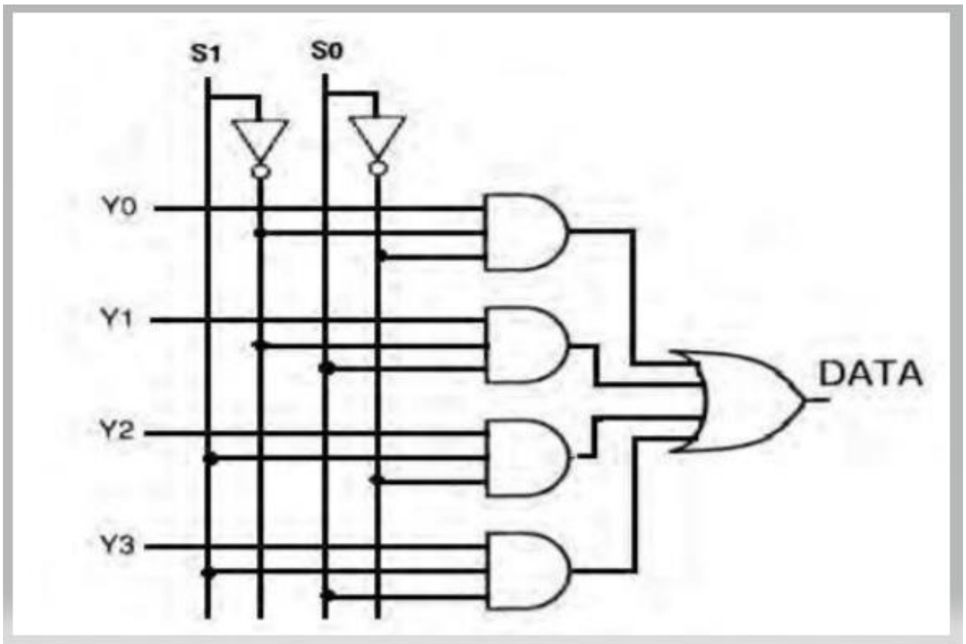

Fig.12 4:1-Multiplexer logic diagram

S1	S0	DATA
0	0	Y0
0	1	Y1
1	0	Y2
1	1	Y3

Table.5 4:1-Multiplexer Truth table.

CHAPTER 6

6.1 SOFTWARE ARCHITECTURE

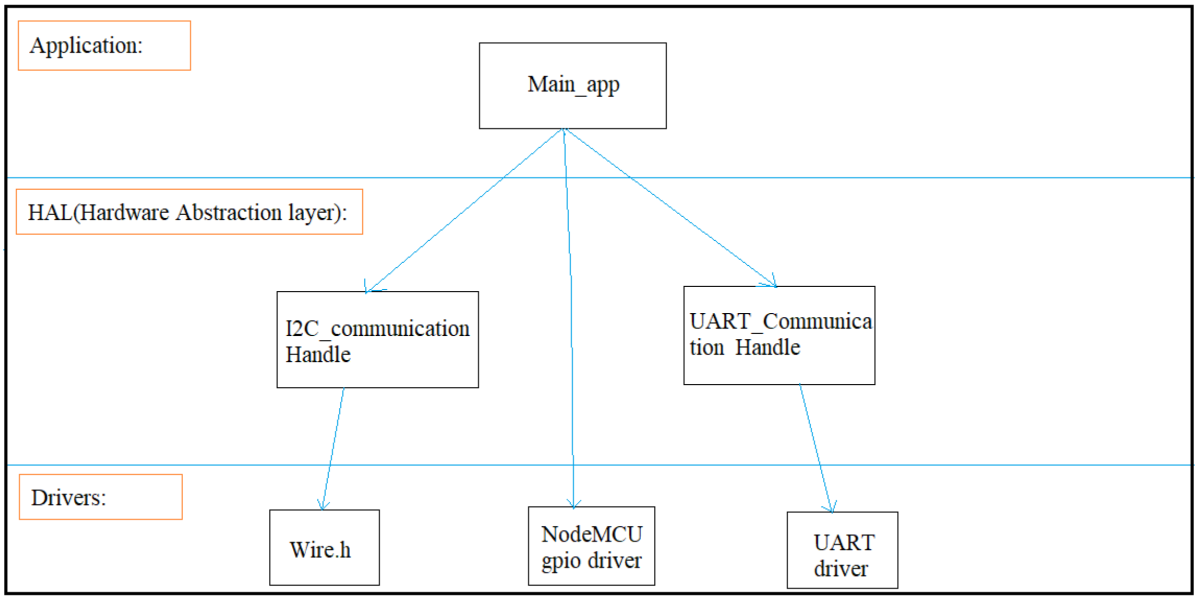

Fig.13 Software architecture of the system (Embedded C platform)

The Software architecture will be broken up into primarily 3 layers:

- Drivers: This will comprise of software components available from the vendor as part of board support package. This will be responsible to program the registers for the functionality. Here the main drivers are the wire.h, UART driver, and NODEMCU gpio drivers.
- HAL (Hardware Abstraction layer): Based on the drivers available, this layer will provide interfaces that is needed to realize the application. On moving to any other hardware, these interfaces will have to remain as it is but the implementation using the respective drivers of the hardware will change. Here hardware abstraction layers are for I2C, UART communications.
- Application: This is the layer which will work based on the use cases that are defined as part of requirements. The application will use the software components in HAL and hence can be hardware agnostic. Here the application layer is the main microcontroller.

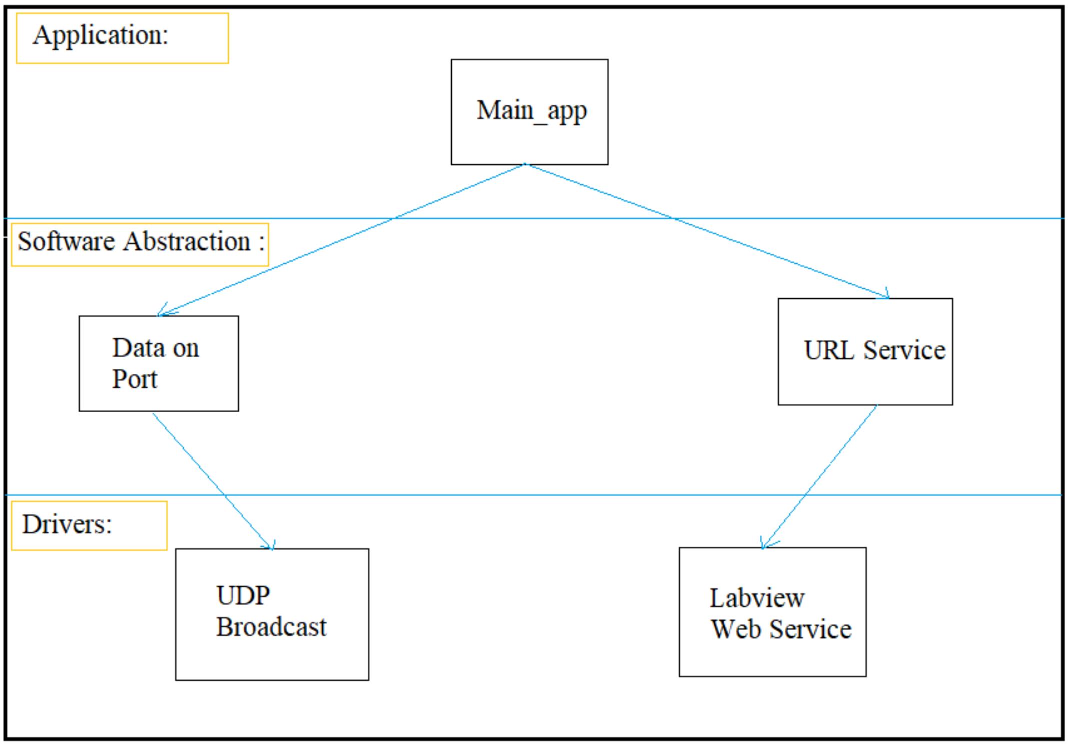

Fig.14 Software architecture of the system(LabVIEW platform)

The Software architecture will be broken up into primarily 3 layers:

- Drivers: This will comprise of software components available from the National Instruments as part of software support package. This will be responsible to program the registers for the functionality of user interface and for communication between the UI and the Embedded system. Here the main drivers are UDp Broadcasting and LabVIEW Web Services drivers.
- SAL (Software Abstraction layer): Based on the drivers available, this layer will provide interfaces that is needed to realize the application. This will encapsulate the hardware that is been based on the UI requirement. Here Software abstraction layers are for Data on port, URL Service communications.
- Application: This is the layer which will work based on the use cases that are defined as part of requirements of the user. The application will use the software components in SAL and hence can be software agnostic. Here the application layer is user interface platform i.e. LabVIEW.

CHAPTER 7

7.1 METHODOLOGY

The project was undergone below steps as follows to achieve the end result:

- To understand the Lab experiments which are considered
- Study ESP8266 working, Variables and variable services
- Study on PCF8574
- Design of PCB for the Hardware stuffs
- Implementing software for an embedded board to test circuits
- Fully fledged final code implementation for the hardware kit.
- A PC user interface to the students and interfacing it to internet
- Communication between Hardware kit and the Student PC

7.2 DESIGN PERSPECTIVE

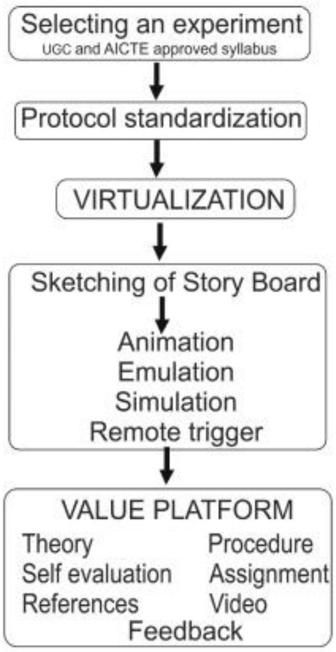

Fig.15 Flow of design

The Flow chart depicts the complete systematic procedure involved in the virtual techniques using IOT. The selected experiment that is operated through the required protocol. The kit is accessed using the common protocol address between the user interface and the cloud. The platform created to depict the result is observed using the interface window or different user application.

In the system single Mother board will be communicating to set of experiments. Reason is there should not be any conflict with the I/Os utilised for the experiments. Inputs are globally defined so that the same inputs can be used for all the experiments.

CHAPTER 8

8.1 USER INTERFACE

User Interface is designed by using the tool LabVIEW. As this tool helps in getting a beautiful pictorial presentation of the concept. It was the era where many of the techies use to code their requirement using cobalt tool later it overcome by C and later by Java. Now its time for graphical presentation where we can use these LabVIEW tool to build our requirement in the manner we want. An exe file of this user interface will be installed in the PC placed in the department lab. Student can access the system remotely by entering the Id of the lab system in their PC. Once the student gets the access, they can enter into the user interface and can proceed with their requirements according to the experiment they need to conduct.

As you can see in the below fig, it gives the front page of the user interface where one can select the respective experiment they need to conduct, and the page will direct to the corresponding experiment page.

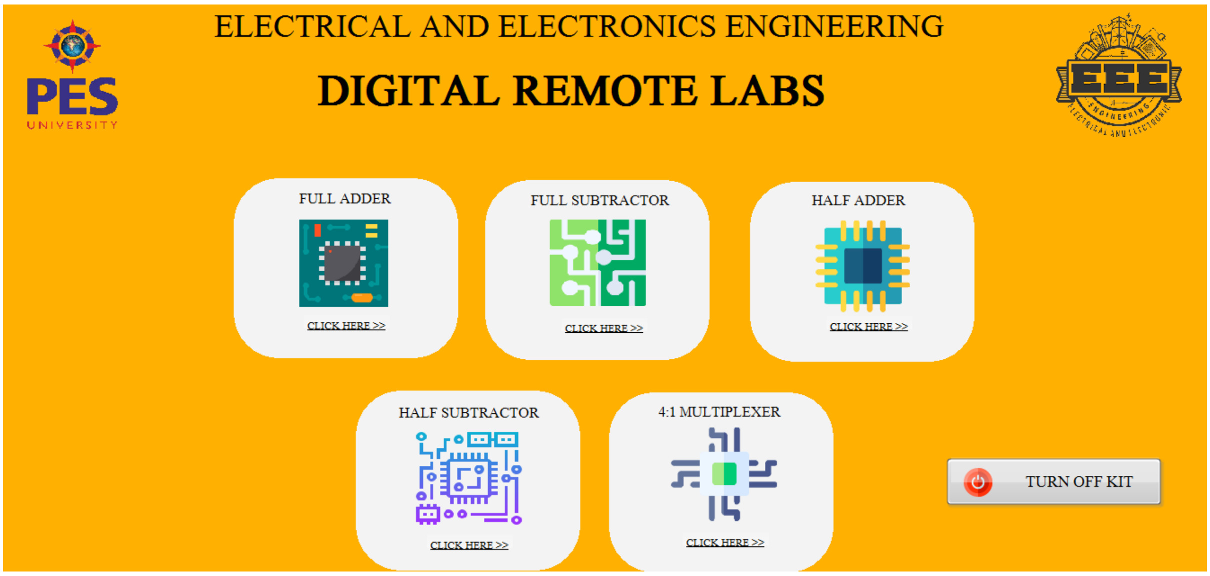

Fig.16 User Interface Dashboard

There the user can see into the option Turn off Kit. This means that when they want to come out of the user interface page whenever they wish one can.

The Figure19 shows the block diagram of the front page of the user interface. It is designed with a while loop and case structure with the sub VI blocks inside it.

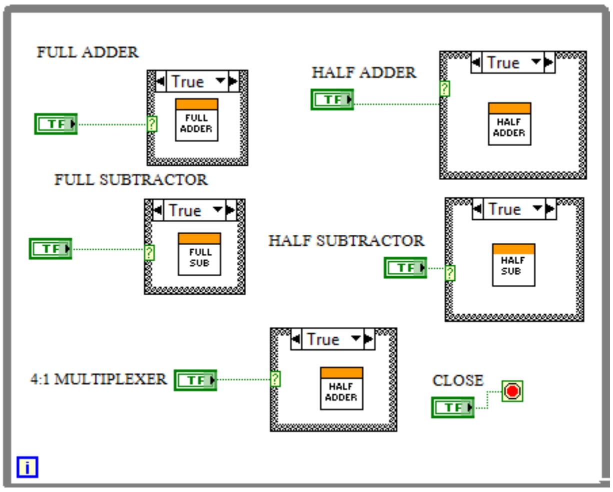

Fig.17 Front page Block diagram of UI

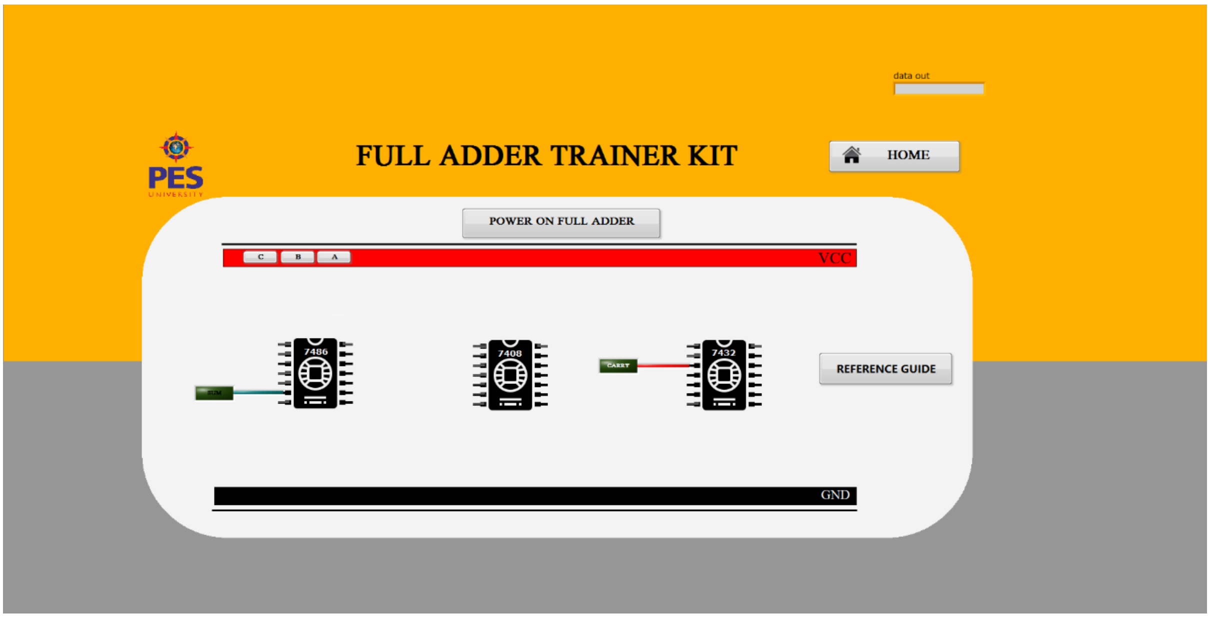

Fig.18 User Interface Dashboard

Figure 20 Shows the Full Adder Front panel. Once the student chooses the Full adder experiment, one will be directed into the panel in the figure.

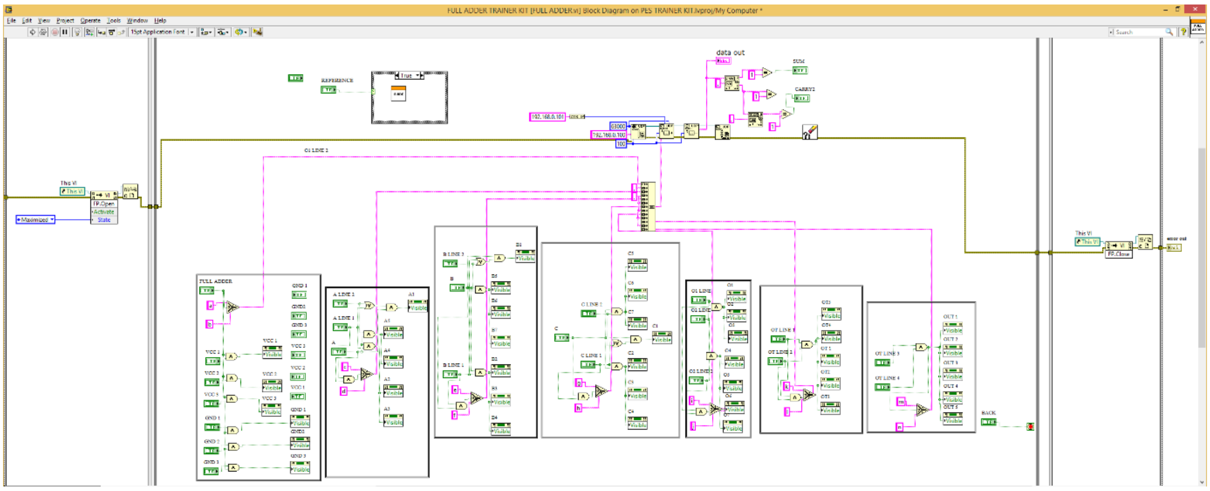

Figure 19: LabVIEW Block diagram for Full Adder

The above Figure 21 shows the LabVIEW block diagram of Full Adder Front panel. For button to perform its functionality I have used true or false selective button in the block diagram. With respect to the buffer coming into the Block diagram from Master the triggering of switch in the circuit board takes place. The data from Master to the LabView will be transfer using UDP broadcast where the dedicated port is assigned for the communication. One can see the Reference Guide option in the front panel. The block for the Reference Guide is designed with case structure in the top of the Block diagram.

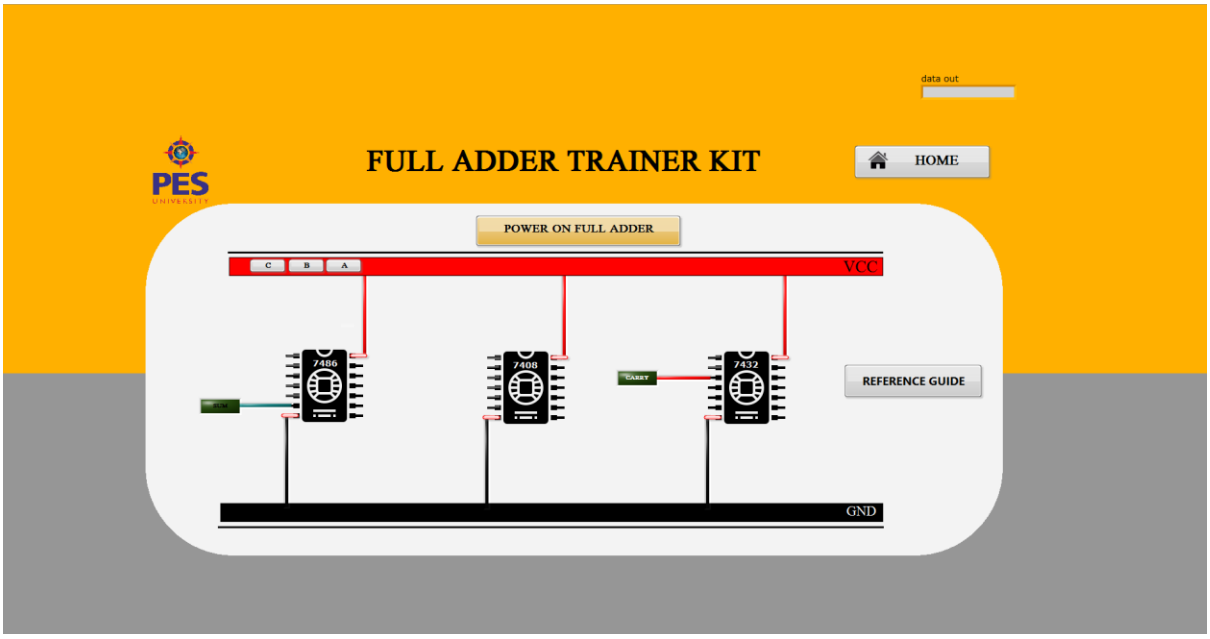

Fig.20 Powering on Full Adder Circuit

Once the User get into the access to the experiment, he needs to turn on the experiment. Figure 22 shows that the circuit is turned when the user press the button Power On button. Now the user can connect the VCC and GND required to their IC's present on the kit. By just pressing on the respective button on the respective IC one can get the IC powered up.

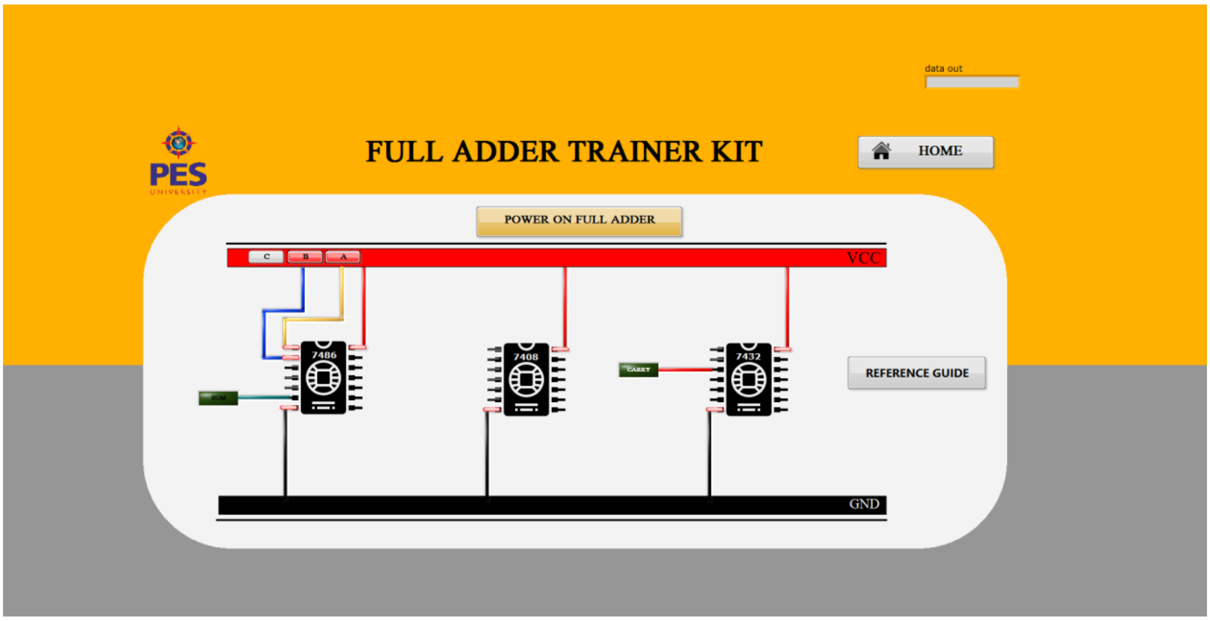

Fig.21 Giving Inputs to the circuit

User can provide input to the circuit by pressing the respective button on the IC. Here in the figure 7486 IC got inputs to its first 2 pins by just pressing the respective button on the IC and on the inputs visible on the user interface. Respective buttons are pressed, and the probe will be drawn automatically between the button pressed with respect to the code designed in the backend.

Respectively all other connections required for the circuit needed to be completed can be done by following the procedure i.e. selecting the proper pin on the IC and clicking on inputs also if one want to short link the connections between to ICs it can also be done by selecting the proper pin and the short link probe will be drawn between the respective pins selected only when the selected pins are correct for the operation. Figure 24 shows the connection of short links and the 3rd input given to the circuit.

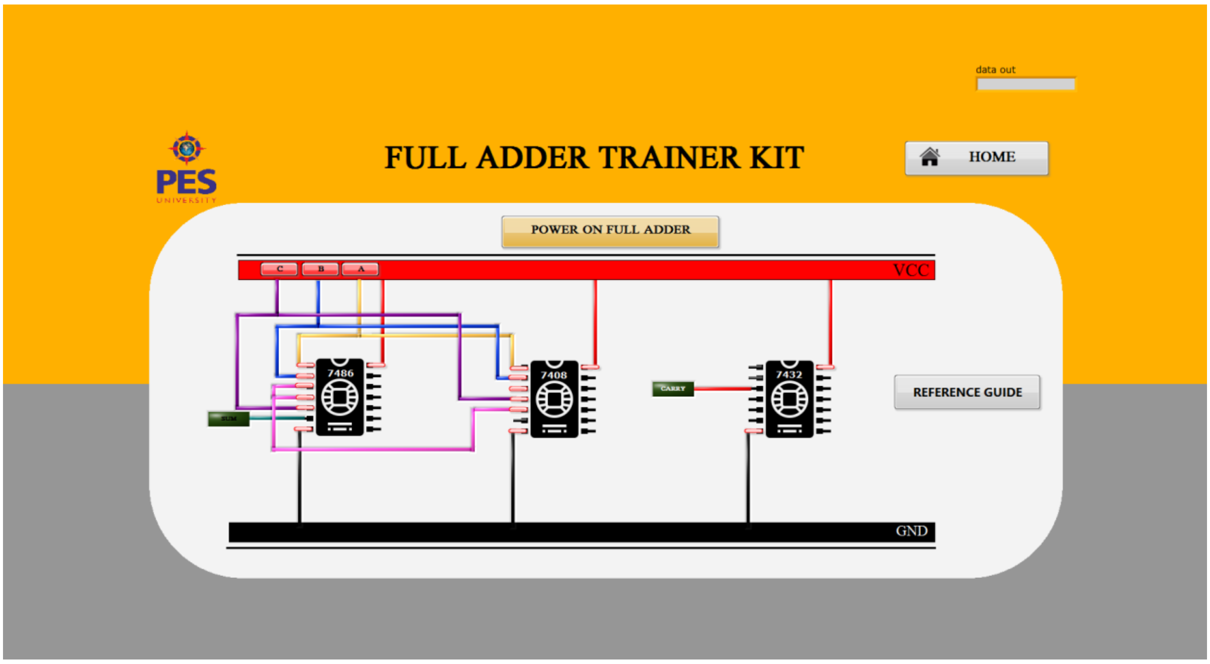

Fig.22 Short link connections between 2 ICs of Full Adder Circuit

Figure 25 shows the complete connection of the experiment Full adder. The connection between respective pins of ICs are connected by selecting the proper pins required for the experiment. 2 indicators present on the front panel indicates the Sum and Carry of the Full Adder experiment. It indicates the result with respect to the input provided. The user can verify the results on the indicator with reference to the truth table provided in the lab manual.

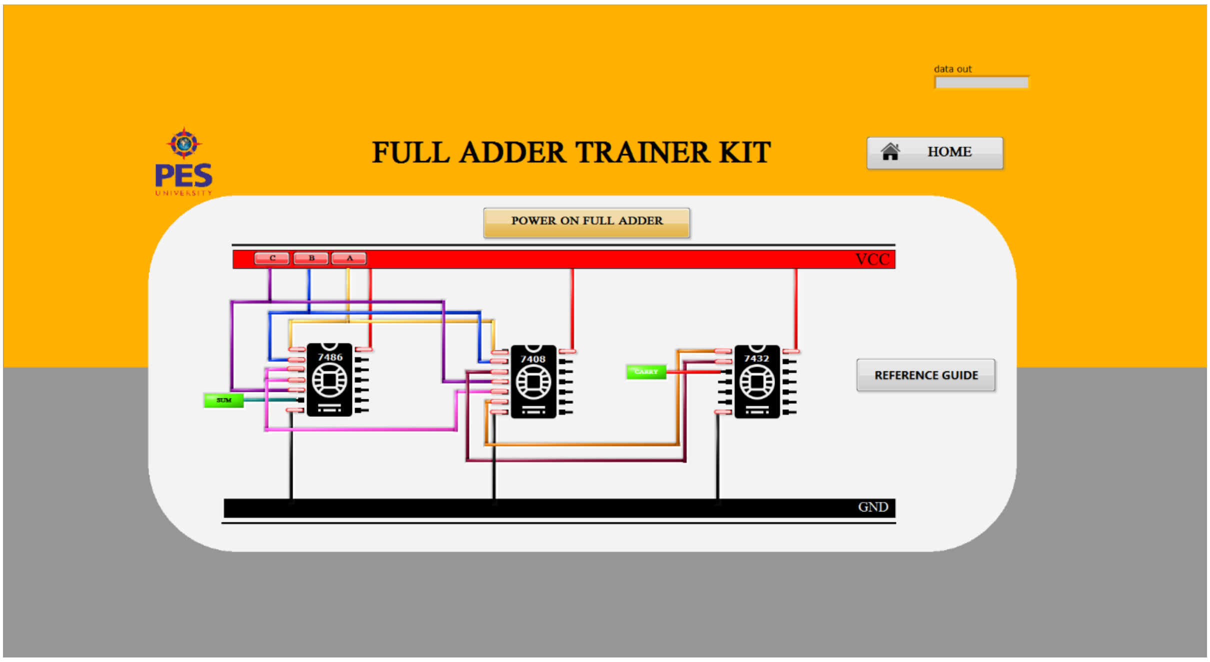

Fig.23 Powering on Full Adder Circuit

Here are some of the results one can find on the front panel with respect to the inputs provided is shown in the figure 26.

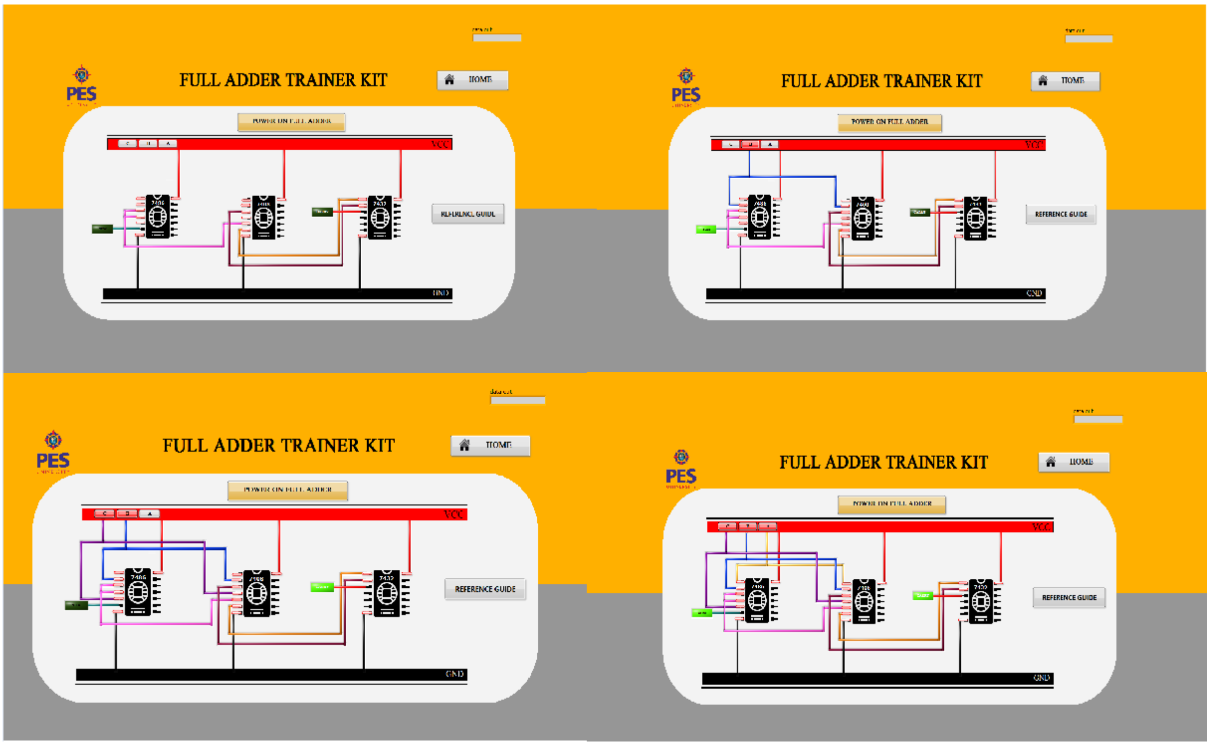

Fig.24 Output results Full Adder Circuit on User Interface

User can also see the option of Reference Guide on the front panel. There one can get the pin details of the ICs used for the respective experiment. The connection of the ICs to the inputs also connection between ICs. The below figures give the look into the reference guide.

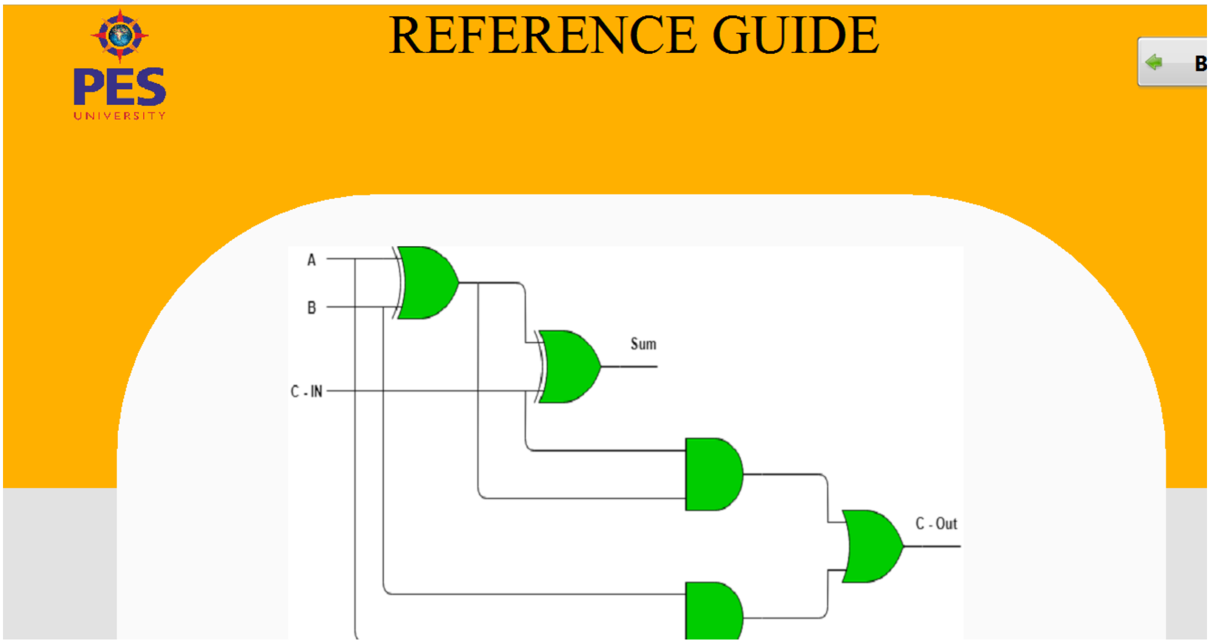

Fig.25 Reference guide window

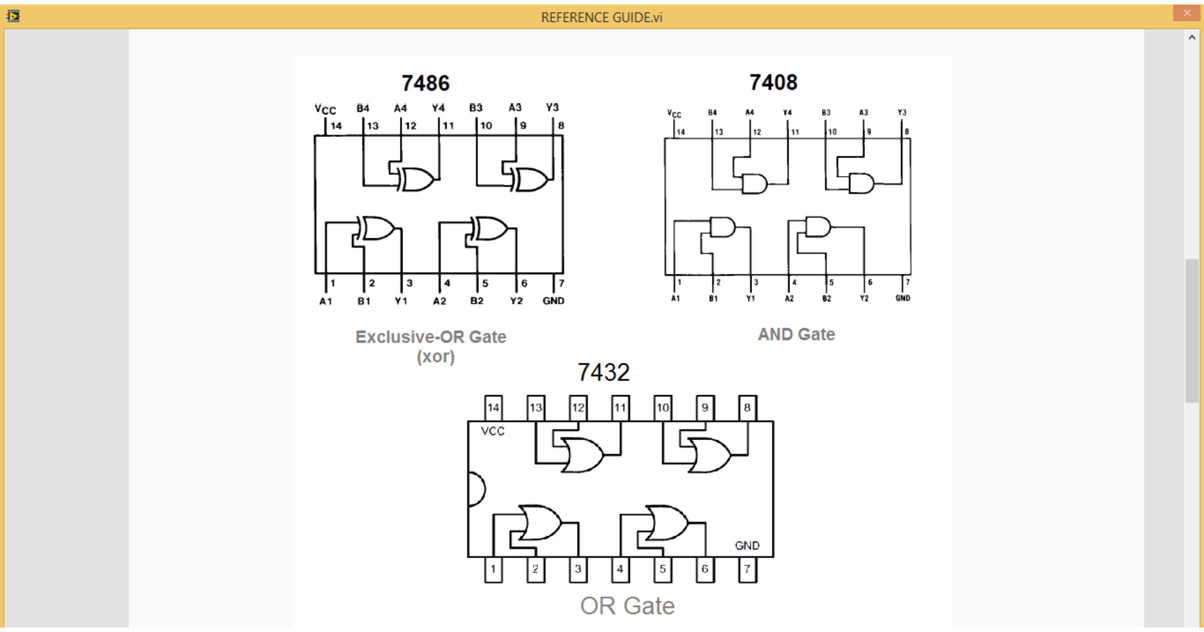

Fig.26 ICs used in respective experiment and its pin details

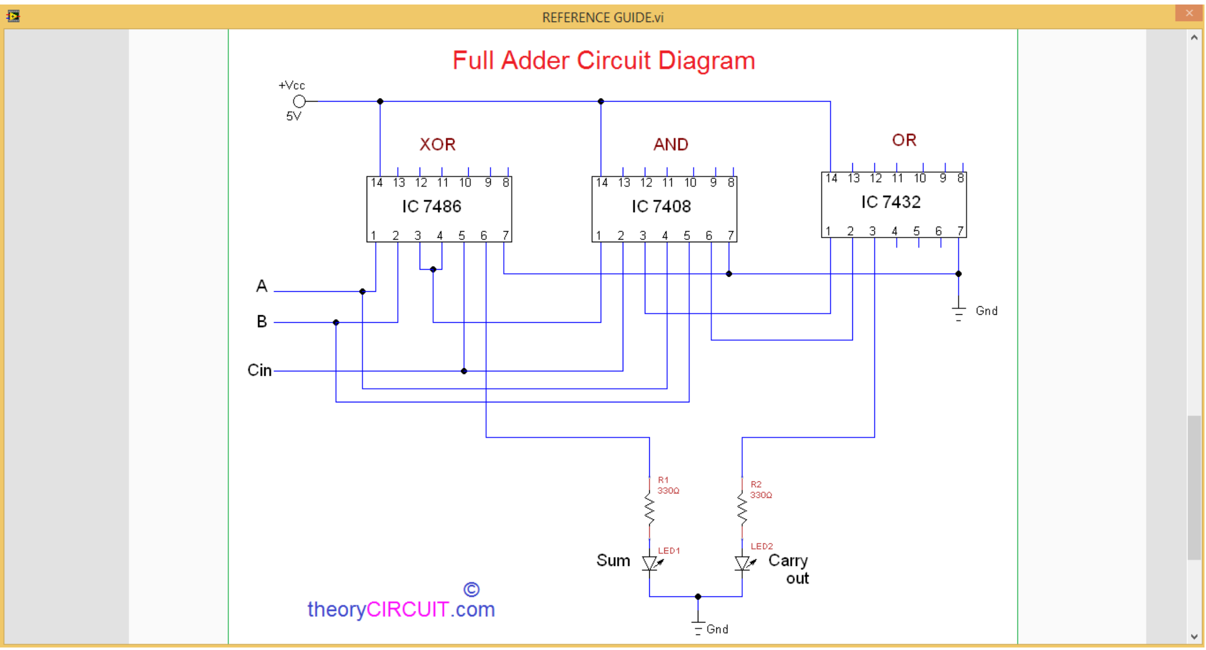

Fig.27 Reference guide having pin diagram and connections of experiment

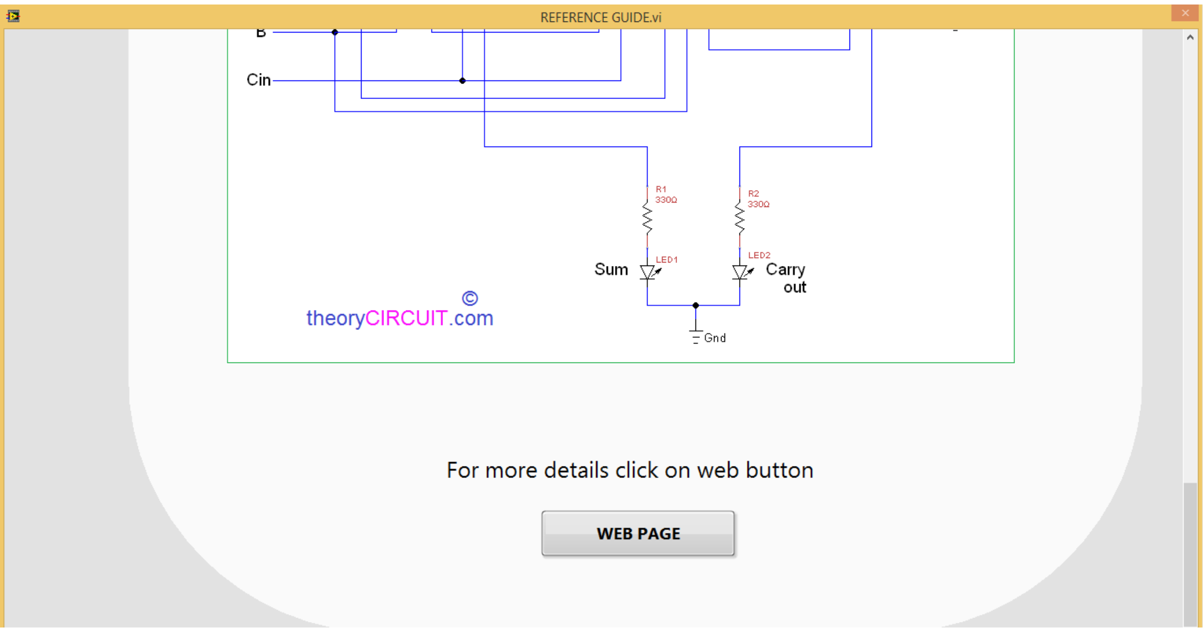

Fig. 38 Web page button for more details

User can see the Web page option where they can find detailed information of the experiment in Figure 30. The User interface takes the user into the respective web page of the experiment he is conducting by clicking on the respective button. Figure 31 represent the detailed page of the experiment directed by the user interface into the web page.

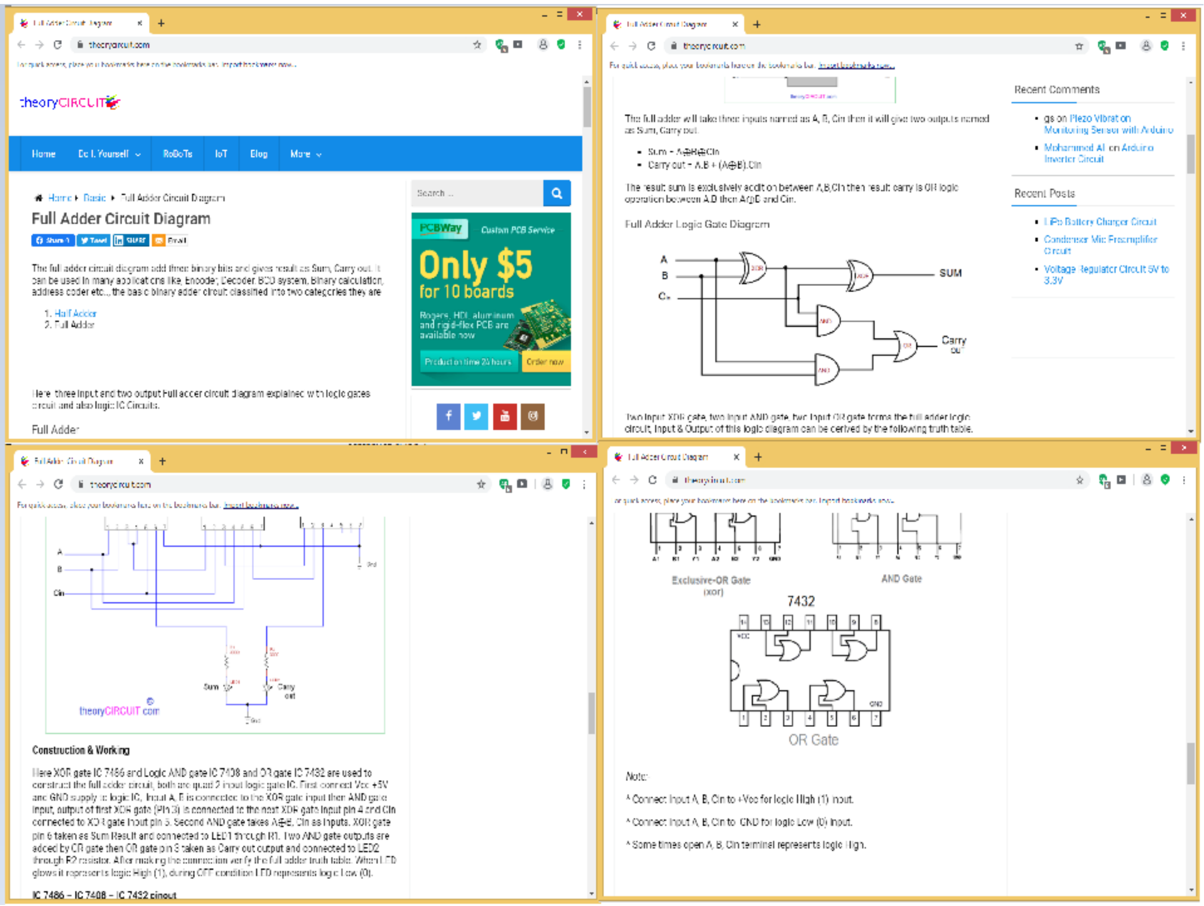

Fig.29 Detailed information of the experiment directed by User interface page

CHAPTER 9

9.1 CIRCUIT CONSTRUCTION

For construction of circuits used in the project I have used General purpose PCB so that the POC i.e. proof of concept can be modified at any point of time according to our requirement. IC holders are used so that for the replacement of ICs and for the maintenance there should not be any inconvenience. Female Bergstrips are used in the circuits to connect the PCF8574. PCF854 can be plugged in and out easily. PBts are used on the circuit for the power supply connection. All the connections are hand soldered and can be reworked easily if there is any. Figure 32 shows the circuit of 5 experiments designed for the project on GPCB.

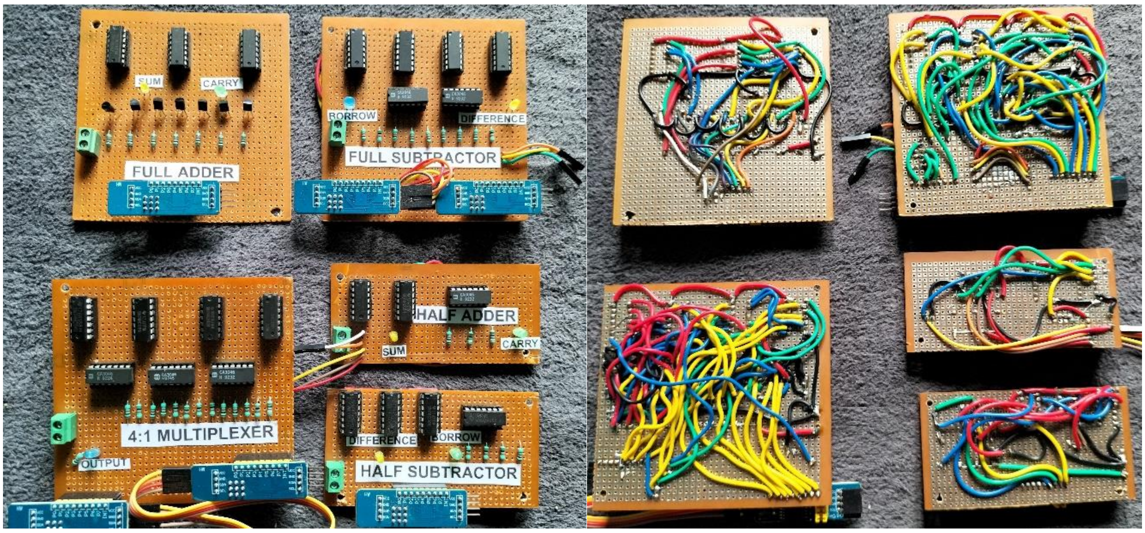

Fig.30 Circuit boards designed for the project

9.2 CAMERA INTERFACE

Why camera?

User can have hands-on feel of the lab not only by using the User interface but also by looking into the actual setup placed in the lab. To achieve this concept, I have used ESP32 CAM module. The module is interfaced with OV2640 camera of 2MP is a very competitive small size that can operated independently. It has a deep sleep current rating of upto 6mA. ESP integrates WiFi, with 2 high performance 32-bit LX6 CPUs.

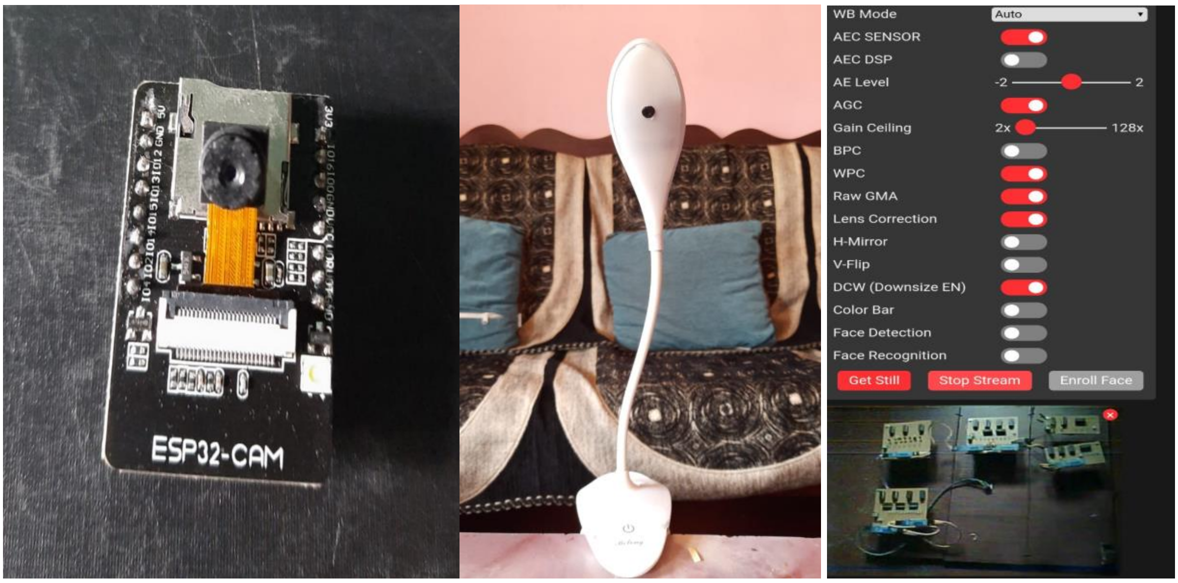

Fig. 31 ESP32 Camera module, mounting structure and on-screen webpage

Figure 33 shows the Camera module used for the project and mounting infrastructure designed for the project which a clip type stand, it can be place easily in which ever the direction user required. Figure 34 shows the camera option on the front panel of the user interface. Pressing on the camera button user can access the camera and can see the indication on the hardware setup. Pressing the button on the UI it will process the page to the URL linked to the portal of the camera screen which is shown in the Figure 33.

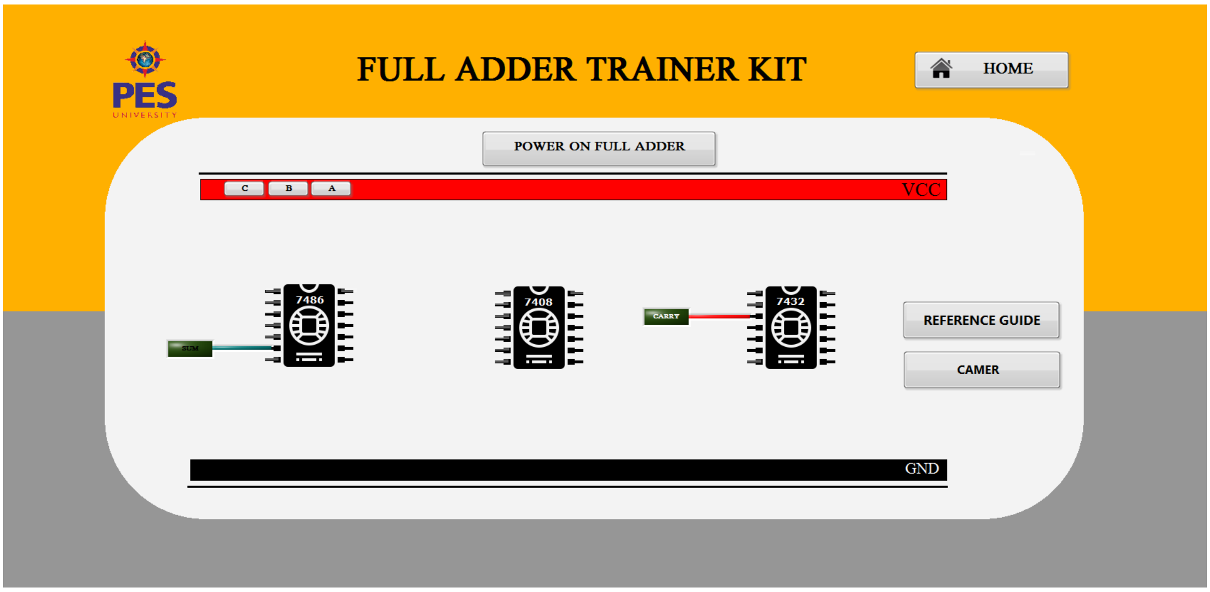

Fig.32 Camera option on the Front panel of User Interface

CHAPTER 10

10.1 HARDWARE CASING

CONSTRUCTION AND DESIGN

Hardware Casing is designed for the dimension 18”x16”. The basement is constructed using plywood and for the visibility of the circuit outer casing is designed using transparent acroleic sheet. The casing gives the feel of glass finishing. For the process of construction of casing tools have been used like cutting drilling and buffering, all are done manually. Figure 35 shows the construction process and glass finish look of the casing.

Fig.33 Hardware casing construction process and glass look finishing

MOUNTING MECHANISM

Mounting of the Circuit bords are done by using spacers, nuts and bolts. Using spacers can help the circuits for ventilation so that air can flow easily throughout the circuit. To the basement rubber bushes are used for the proper placement of the kit on the table. Figure 36 shows the mounting mechanism of the circuit on base board.

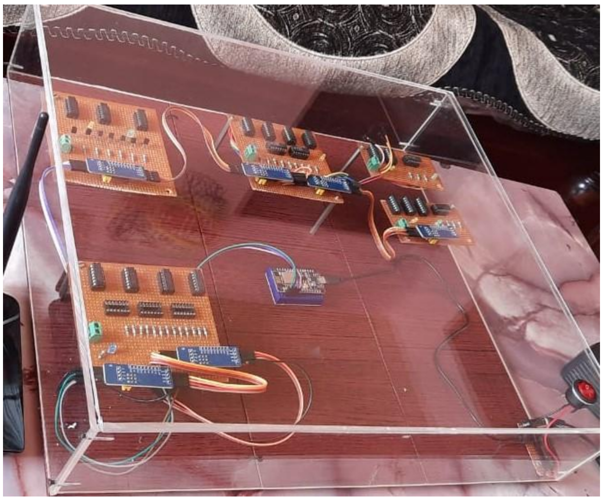

Fig.34 Mounting mechanism of the circuits

10.2 DIGITAL LAB KIT

Figure 37 shows the overall look of the Remote Digital Lab Kit. The Kit will communicate to the Student remotely and the system is in contact with the Lab PC via Wi-Fi connection.

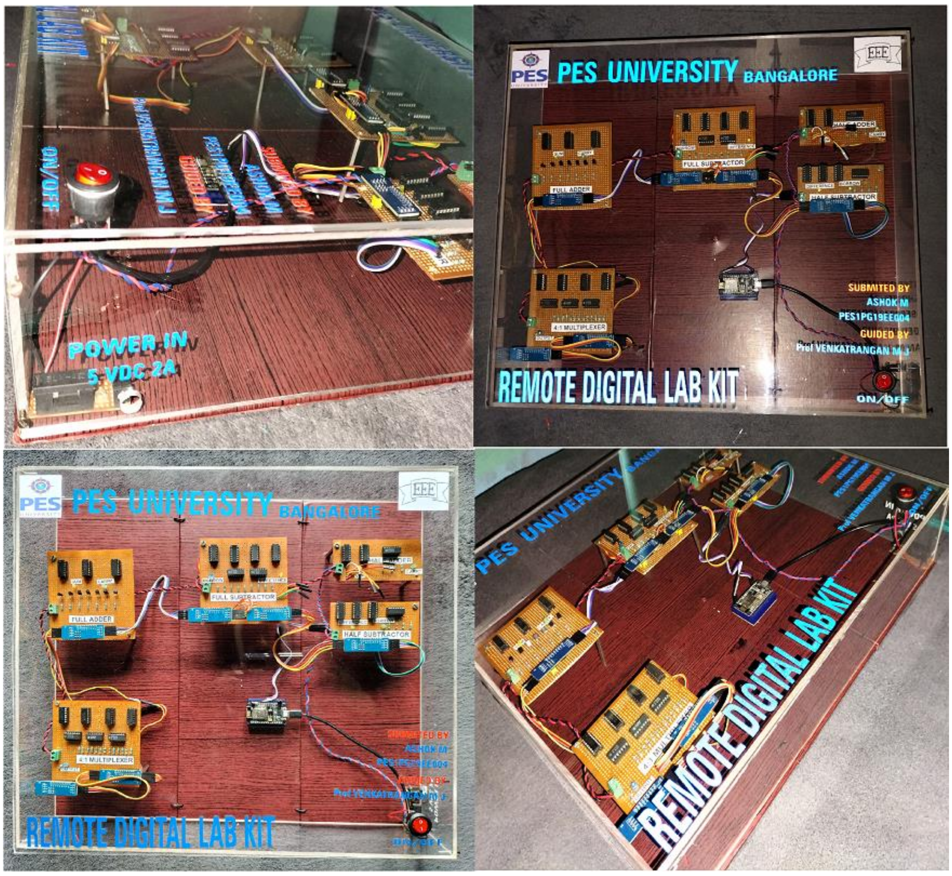

Fig.35 Over all look of the Remote Digital Lab Kit

A 5v DC switch is given to the kit. The switch will be turned on 24/7 so that student can access the system at any instant of time. A 5v 2A fuse also provided for the protection of the kit.

CHAPTER 11

11.1 RESULTS

A kit for Digital Lab is designed and can accessed remotely. The operations are controlled using the User Interface. The digital output can be observed on the kit as well as on the User Interface.

Fig.36 Off mode of Remote Digital Lab Kit

The Virtual trainer kit is rigged up with the wires for the experiments and their outputs seen on the user interface as well on the kit is shown in the figure.

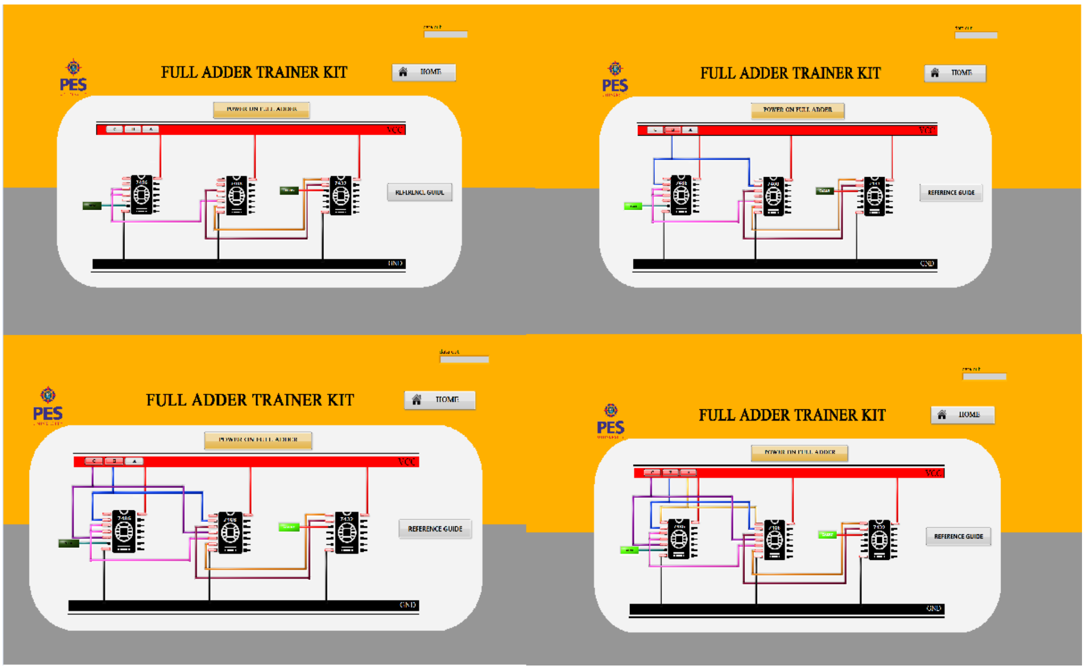

Fig.37 Virtual rig up of the circuit for experiment 1

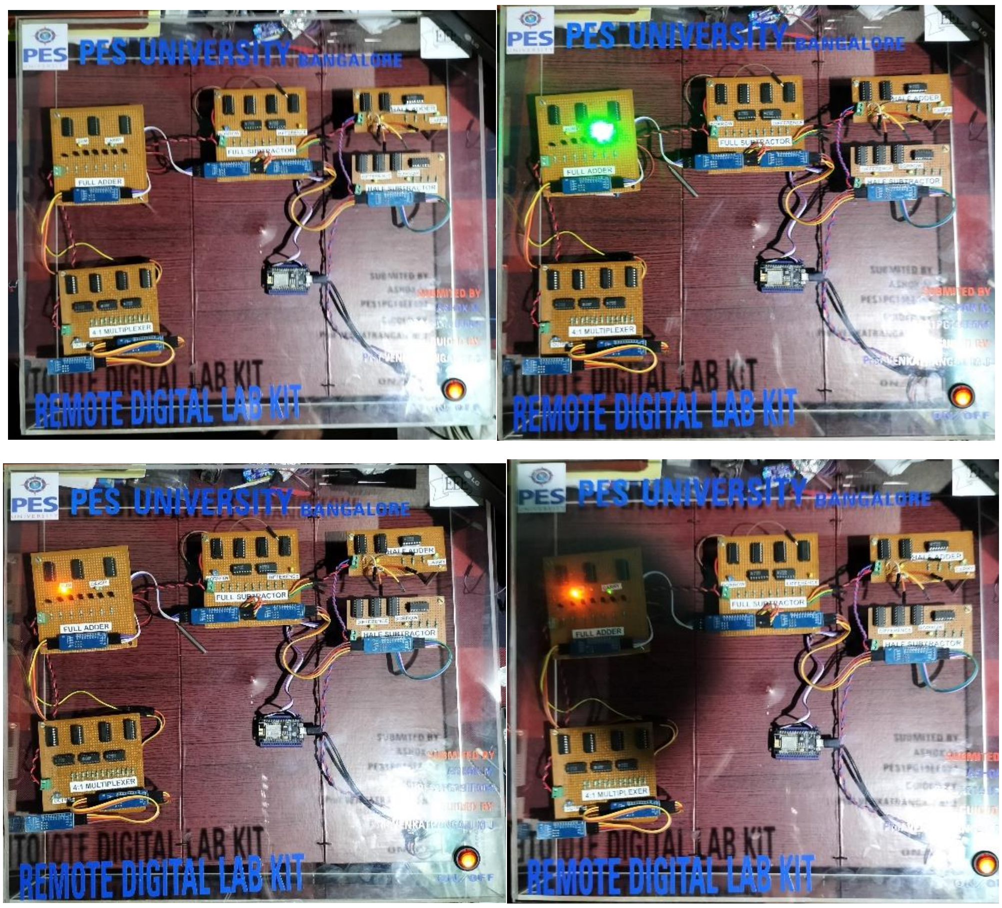

Fig.38 Output on LED of Remote Digital Lab Kit

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