Implementation of Smart Gas Controller on a Reconfigurable Hardware

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***Abstract*— Elderly people face the issue of controlling the LPG gas knob operation in timely manner resulting in improper cooking, over cooking which mess up the food taste. It is observe in that often they need assistance from their associations for appropriate control of the knob for Sim and Turning Off. This project aims to develop a device that assists in timely control of the gas knob using a smart phone. This project aims to develop a automatic gas stove controller that helps in controlling the GAS knob positions (High, Sim, OFF) with a mobile unit. The proposed design consist of a Smart phone for monitoring and controlling the gas knob position with the help of commercially available off the shelf components (DC Motor, FPGA and Bluetooth Module). As control of the LPG knob is assumed within the house premises, Blue technology is used. A controller engine is developed in the FPGA.**
KEYWORDS - FPGA, Bluetooth, Smart phone, Torque.

1. INTRODUCTION

It is often observed that women need to spend more time in the kitchen for cooking. Various activities in the kitchen increase temperature making people uncomfortable especially during summer. Also required timely monitor of the gas stove knob position without which the food taste spoils. We need a mechanism that monitors and send various information about the condition of the kitchen in timely manner . [1]

Smart home automation technology allows the user to control the home appliances using wireless communication devices, which improve the comfort of the user. RaspberryPi, Micro controller based hardware platforms are used in such designs. [2,3,4]

Smart Phone supports wireless protocols such as Wi-Fi, Bluetooth. SMS notifications, vibration are common and the mobile need not require additional alarming devices for warning to the user. Cell phone based commands use to remotely switch off the LPG Gas stove. [5]

Home appliances communicate using Bluetooth which is a wireless communication technology for short distance communication. Bluetooth enabled devices can remotely be operated using a Smart Phone for controlling the home appliances. Unattended, unintended gas flow occurs if the gas knob is left opened without an ignition to start the fire. [6,7]. GSM based home automation using Temperature sensor, Gas sensor with a FPGA is discussed. [8].

Automatic gas stove for presence of vessel, Switch OFF the flame during the absence of the vessel, and safety features generation of during the LPG leakage, message generation in the event of to a registered mobile number is discussed. [9] Digital display of cookers for cooker display, timer to off the gas stove is discussed [10]

The main objective of this project is to facilitate the elderly and the handicapped people, to perform their daily tasks of cooking and controlling the LPG gas stove from a remote place within the house. It improves the comfort, the safety.

The proposed solution implements a smart gas controller consisting of an FPGA board, Bluetooth module (with built in Bluetooth stack) to control Gas Stove Unit and to monitor the position of Gas stove. Position control logic is developed to process the control commands issued from a mobile. The shaft of gas knob is controlled by a DC motor according to the received control commands issued by the user.

This paper is organized as follows. In section 2, a system overview of the implementation is introduced. Section 3 description of Controller engine, Section 4 shows the Simulation results and Section 5 the Hardware setup and the results. Section 6 deals with the conclusion and the Future scope the Future scope is in Section 7.

2. SYSTEM OVERVIEW

Top level block diagram consists of Mobile unit(GUI) for transferring control commands, Bluetooth Module, Controller Engine, DC Motor & shaft coupler, LPG gas knob, is shown in Fig.1.

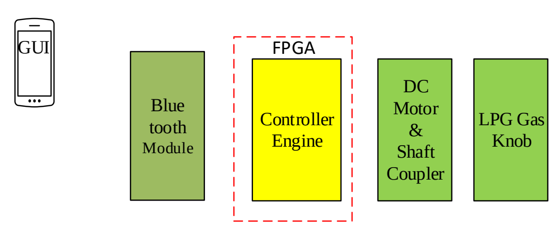

Fig.1. Top level Block diagram

A. Mobile

A smart phone with Android operating system is used to send the user commands: switch 01, switch 02, switch 03 for controlling the LPG gas knob in High, Sim and Off positions respectively. The Mobile receives the current position of the Gas Knob.

B. GUI

The user sends the control commands through a Graphical User Interface (GUI) developed using "Bluetooth Terminal" app. The commands use a custom format between the mobile and the FPGA system. The GUI with sample control commands is shown in Fig.2

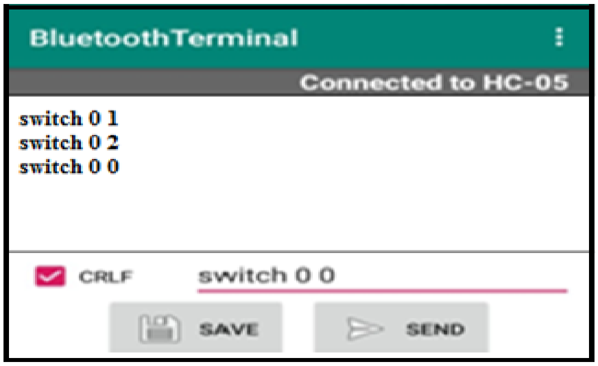

Fig.2.Graphical User Interface (GUI)

C. BT Module(Bluetooth module) BTHC05

It has Bluetooth stack with a serial interface. It has master, slave configuration modes. Initialization process of the module (38.4 Kbps baud rate) is shown below.

i. The module is set as Master and the mobile acts as in Slave mode.

ii. Bind and Pair commands to be issued for Pairing between the module and the mobile unit.

iii. After the successful pairing, the module to be set as Slave.

After successful initialization, bidirectional data communication take place at 9.6 Kbps baud rate. "Bluetooth Terminal" is an Android Application, with Smartphone.

D. **Controller Engine**

It communicates with the Bluetooth module for processing the commands issued by the mobile unit and issues timely commands to the DC Motor.

E. **DC Motor**

It is a Bipolar, geared DC motor with 8kgcm Torque. It drives the gas stove knob with a coupler and works as per the user commands.

3. CONTROLLER ENGINE

Controller engine code is developed in Verilog HDL and ported in FPGA. The module communicates with the Bluetooth module and sends the timely control commands issued to the DC motor. Detailed block diagram of the module is shown in the Fig.3.

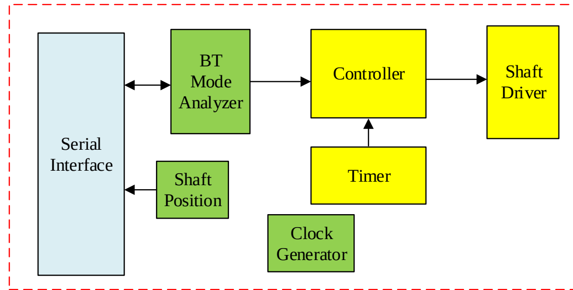

Fig.3. Detailed Block Diagram of Controller Engine

F. Serial interface:

It communicates with the Bluetooth module via Serial Link and sends the user issued commands to the BT mode Analyzer. It sends the shaft position status to the user.

G. BT mode analyzer:

It is responsible for Bluetooth module pairing (at 38.4 Kbps), Data communication (at 9.6 Kbps) with the user.

H. Controller:

It receives the processed data from BT mode analyzer and issues timely control logic to drive the Shaft Driver module. Which in turn drives the DC motor using a Bi-polar dual H-Bridge driver module.

The controller module implements a position controlling logic, the flow Chart is shown in Fig. 4. It runs after the Bluetooth Module is initialized, Binding and Pairing with the Mobile is completed. The logic works with the gas shaft is in initial state (OFF).

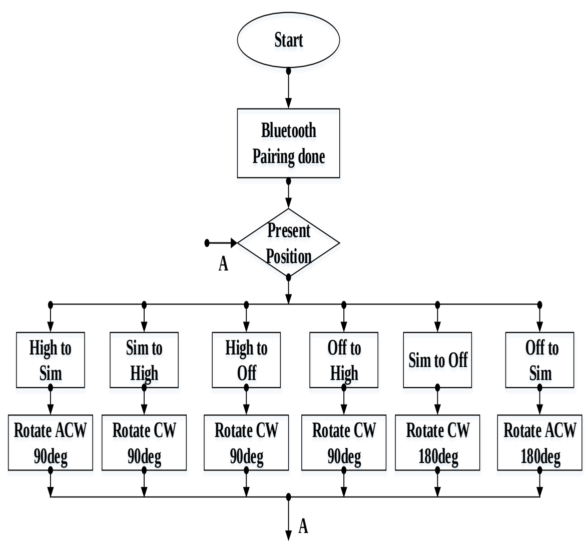

Fig .4: Flow chart for position controlling

4. SIMULATION RESULTS

The design is developed in Verilog HDL and it is simulated, synthesized with Xilinx 14.3 ISE. The simulation results of Off to High (switch 01), High to Sim (switch 02), Sim to Off (switch 03) position are shown in Fig.5, Fig 6, Fig. 7.

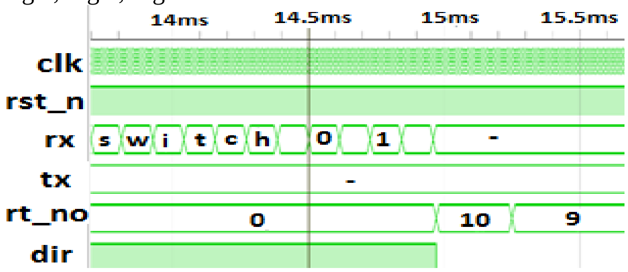

Fig.5 Off to High Position

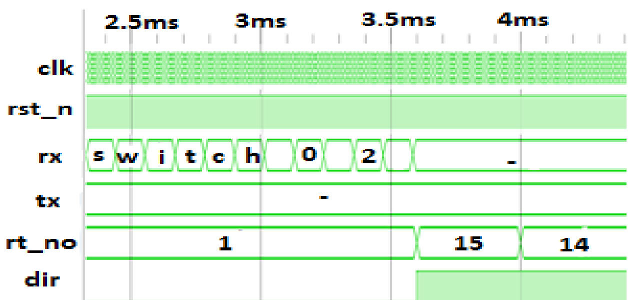

Fig. 6 High to Sim Position

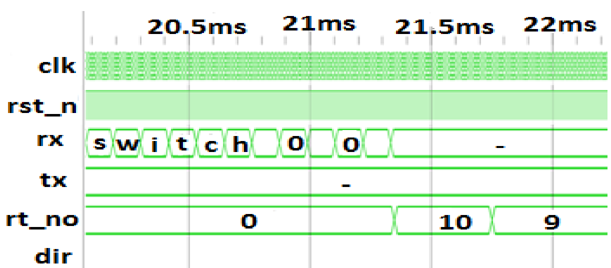

Fig. 7 Sim to Off Position

The control commands are transmitted to BT Module. Controller engine receive through Bluetooth module and controls gas stove shaft to Sim, High and Off positions. Position controlling algorithm is responsible for choosing position control commands. Captured position control commands are shown in Table I.

5. HARDWARE SETUP AND RESULTS

The design is validated on Xilinx Spartan 3-E FPGA development board. The Hardware setup for validation along with the Gas stove unit is shown in the Fig.5.

Fig.5: Hardware setup for system control

Device utilization summary:
Synthesis results are shown in Table I.

Table I. Device utilization table

S.No	Description	Used	Available
1.	Number of Slices Registers	373	4,656
2.	Number of bonded IOBs	20	232
3.	Number of 4 input LUTs	697	9,312
4.	Number of BUFGMUXs	2	24
5.	Number of occupied Slices	398	2,448
6.	Number of Slices containing only related logic	398	761

Target device: xc3s500e-5fg320.

Timing Summary:
Speed Grade: -5
Minimum period: 7.052ns
Maximum Frequency: 141.800MHz
Minimum input arrival time before clock: 5.498ns
Maximum output required time after clock: 4.433ns

6. CONCLUSION

In this paper, we have proposed a Smart gas controller and its architecture is detailed. The simulation results and the validation is carried on Xilinx Spartan 3-E FPGA development board. Gas stove knob is successfully operated with the design for Sim, High, Off positions.

A maximum operating Frequency of 141.8MHz with device occupancy of 373 slice registers is achieved.

7. FUTURE SCOPE

The proposed work could be extended to a high end LPG gas stove knob control, which needs less Torque, so miniaturization of the controller circuitry is possible. Milk spilling during boiling of the milk, Gas leakage detection can be added to the design with a little hardware.

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