Design and Analysis of Controller for Vehicle Ignition using FPGA

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Abstract

High death rates are observed after accidents due to non-wearing helmet of driver with two-wheeler. Many studies on statistics data for various parts of world had been carried out which clearly supports this statement. A new approach to address this issue along with the authentication of ownership of vehicle is proposed, which is designed in such way unless an authorized person with RFID tag wears the helmet the vehicle will not be ignited. The paper focuses on the chip design and implementation of hardware system on FPGA for vehicle. The high speed controller is designed Xilinx 14.2 ISE software with the help of VHDL programming language and synthesized on Virtex-5 FPGA. Modelsim 10.1b is used for the function simulation to test the different test cases. The developed system supports the frequency of 781.250 MHz, which is proposed as optimal solution for the intelligent system.

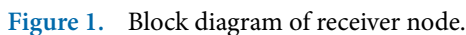**Keywords:** Authentication, Controller, FPGA Safety, Two-Wheeler

1. Introduction

Author in[1] shows the study of helmet laws and its impact on head injury prevention from 1979 to 1986 at United States. The result shows fewer death rates with helmet law than without law regardless of the population and motorcycle registrations. Also disagreement on such laws has been observed. Houston, Author in[2] shows the statistical data study for the effectiveness of universal helmet law on the six states of US for a period of 1975 to 2004. Data shows extra 615 fatalities of motorcyclist due to changes in the helmet laws. Author in[3] shows the study on the risks with high powered motorcycles when used by the young adults for a time span of 2002 to 2009 in Britain. The study concludes that the engine size restrictions can reduce the risk of death, also health warning should be introduced at policymaker end[3]. Author in[4] shows the study on the effect road conditions and behaviour of driver on crash rates in Australia. Paper concludes that the study of road crash must consider road geometry with time of day/night to set the statistical data for national survey[4]. Author in[5] describes the study of behaviour of parents after a safety program named "Zahav Bagan" for kindergarten children conducted by senior citizens. The objective was to observe the behavior of the parents who has gone through program and who doesn't opt for the program on safety of kindergarten. Results show no change in the knowledge of parents on road safety laws but they show more awareness towards the safety[5]. Author in[6] describes a novel approach for safe drive for two-wheeler. The system designed in such a way that vehicle will not be started unless driver wears the helmet also in case of accident it sends the message to pre defined number with the location. The system also comprises of Iris sensor for authentication of the owner[6]. Author in[7] describes the concept of environmental pressure monitoring to identify tidal range in high alert areas with the help of Zigbee based Wireless Sensor Networks (WSNs) and piezoresistive pressure sensor. The system is designed with the help of AVR microcontroller[7]. Author in[8] suggests Zigbee protocol based vehicle tracking system. The proposed system comprises of RFID tags with each vehicle with unique ID, RFID readers at appropriate locations are to be installed and whenever vehicle crosses the reader, information about vehicle sends to control room using Zigbee[8].

2. System Description

A system for two wheeler is designed which ensures the authentication for vehicle and safety of the driver. The whole system comprises of two sections- Helmet node and two wheeler or receiver nodes. In the paper two-wheeler is also addressed as (Scooty). A helmet section four flex sensors are used for measuring the appropriate pressure exerted by head when wear by driver and the node sends this information to two wheeler section through RF modem (Zigbee). The two-wheeler as shown in Figure 1 comprises of controller, RFID reader and RF modem. The two wheeler node receives the data from helmet section and a cumulative decision is taken on the bases of RFID tag (authorized person) and the pressure information from helmet. If the data received from helmet and RFID tag matches with predefined data then only vehicle will be ignited through a relay.

Figure 1. Block diagram of receiver node.

This paper focuses only towards the controller design for the receiver node. The paper focuses on the chip design and implementation of hardware system on FPGA.

The controller is designed for receiving the data from RF modem and twelve byte data from RFID tag. Then this data is compared with threshold value and depending on this Scooty status will be "ON" or "OFF". The RF modem is a communication module with a range of 30 meters. Due to non-dependency on line of sight the RF modem is superior to IR modem.

3. Results and Discussion

The controller is designed with the help of Xilinx 14.2 ISE software using VHDL programming language. The designed system is synthesized on Virtex-5 FPGA. To test the different cases the Modelsim 10.1b simulation is done and results are analysed.

The RTL view transmitter section of the receiver node is shown in Figure 2. It depicts all the possible inputs and outputs of the design and internal architecture is shown in Figure 3. The detail of the pins is discussed in Table 1.
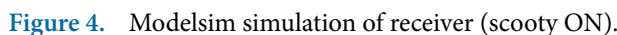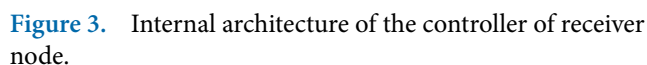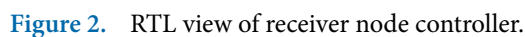

Figure 2. RTL view of receiver node controller.

Figure 3. Internal architecture of the controller of receiver node.

Figure 4. Modelsim simulation of receiver (scooty ON).

Table 1. Pin description of controller of receiver node

Pin	Function
Baud_rate<31:0>	It is the input enabled with transmitter section to decide the baud rate to transmit and receive data
External_RFID_in <95:0>	Input module to receiver as external data as RFID input of 12 byte
RFID_Select<2:0>	Selection logic for the RFID comparator to select the comparison operation
RF_Modem_Rx_ in<9:0>	The Transmitted outputs displayed correspond to LCD section in transmitter side.
RF_select<2:0>	Selection logic for the RF comparator to select the comparison operation
Threshold1<9:0>	Input to the receiver section and threshold for RF modem receiver that compare the RF received value of 10 bit
Threshold2<95:0>	Input to the External RFID module and decides the external threshold to compare the 12 byte input data from RFID
Clk	Input to give the clock signal at the transmitter end
Reset	Input to give the reset signal in synchronization to clock input signal
Scooty_status	Output to enable the two wheeler in On and Off state

The modelsim simulation of the receiver section to enable Scooty in ON and OFF condition is shown in Figure 4, 5 and 6.

Figure 4 and 5 shows the simulation when the sooty is in "ON" condition and Figure 6 shows the result when

scotty is in "OFF" condition. In the simulation results realy_on_off is intermediate between the Scooty_status and comparative output. The baud rate is 9600 bps as RF modem operates on this baud rate. USART_RF is the comparative output of the RF_comparator which accepts RF_Modem_Rx_in<9:0> and thrshold1. USART_RFID is the comparative output of RFID comparator the External_RFID_in [95:0] and thersold2 [95:0]. The status of Realay_ON_OFF is decided based on AND operation of USART_RF and USART_RFID and the status of Scooty in ON/OFF is decided.

Case 1: Baud_rate<31:0> = 9600, External_RFID_in <95:0> = 1'd4000 (decimal), RF_Modem_Rx_in<9:0> = 200, Threshold1 =100, thresold 2 = 1'd 2000 (decimal) then output USART_RF = '1', USART_RFID = '1', Relay_ on_off = 1and scooty_status = '1'. Scotty is on.

Case 2: Baud_rate<31:0> = 9600, External_RFID_in <95:0> = 1'd5000 (decimal), RF_Modem_Rx_in<9:0> = 300, Threshold1 =100, thresold 2 = 1'd 2000 (decimal) then output USART_RF = '1', USART_RFID = '1', Relay_ on_off = 1and scooty_status = '1'. Scotty is on.

Case 3: Baud_rate<31:0> = 9600, External_RFID_in <95:0> = 1'd6000(decimal), RF_Modem_Rx_in<9:0> = 300, Threshold1 = 100, thresold 2 = 1'd 2000 (decimal) then output USART_RF = '1', USART_RFID = '1', Relay_ on_off = 1 and Scooty_status = '1'. Scotty is on.

Case 4: Baud_rate<31:0> = 9600, External_RFID_in <95:0> = 1'd7000(decimal), RF_Modem_Rx_in<9:0> =
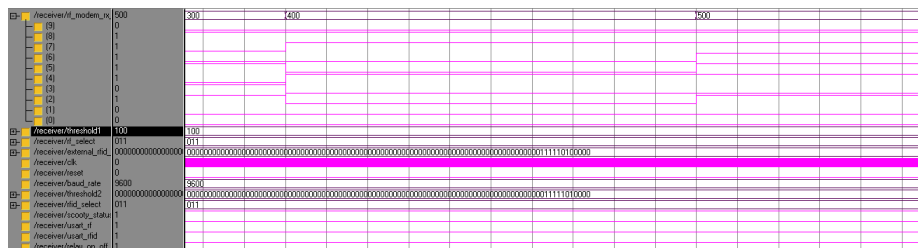
Figure 5. Modelsim simulation of receiver (Scooty ON).
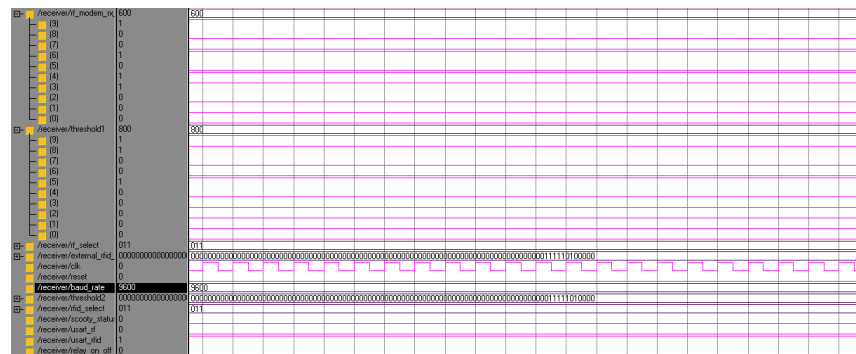
Figure 6. Modelsim simulation of receiver (Scooty OFF).

200, Threshold 1 = 100, thresold 2 = 1'd 2000 (decimal) then output USART_RF = '1', USART_RFID = '1', Relay_on_off = 1 and scooty_status = '1'. Scotty is on.

Case 5: Baud_rate<31:0> = 9600, External_RFID_in <95:0> = 1'd4000(decimal), RF_Modem_Rx_in<9:0> = 200, Threshold1 = 800, thresold 2 = 1'd 2000 (decimal) then output USART_RF = '0', Relay_on_off = '0'and Scooty_status = '0'. Scotty is OFF.

4. FPGA Synthesis Report of Receiver

The design is synthesized on Spartan-6 FPGA. The target device is Xc6slx-45-2csg324. The hardware summary report shows the utilization of LUTs, Flip flops, inputs and output, value of slice registers and buffers and CPU memory etc. The timing values show the value of minimum and maximum clock timing and frequency support.

Timing Summary:
Speed Grade: 2.
Period value minimum: 0.980ns.
Frequency Value as maximum: 781.250MHz.
Arrival time value before clock as minimum: 6.312 ns.
Output time required after clock as maximum: 5.214 ns.
CPU memory usage is 249452 kilobytes.

5. Conclusion

The controller for the proposed system is designed with hardware description language environment and results are analysed with Virtex-5. The simulation results shows that the receiver controller operates on frequency of 781.250 MHz which is very high as compared to existing controllers for example AVR Atmega-16 works on maximum frequency of 16 MHz which shows high speed of designed controller. The minimum period value is observed as 0.980 ns, arrival time before clock as

Table 2. Hardware summary report of receiver

Receiver Project Status			
Project File:	ADC.xise	Parser Errors:	No Errors
Module Name:	Receiver	Implementation State:	Synthesized
Target Device:	xc6slx45-2csg324	• Errors:	No Errors
Device Utilization Summary (estimated values)			[-]
Logic Utilization	Used	Available	Utilization
Number of Slice Registers	2	54576	0%
Number of Slice LUTs	249	27288	0%
Number of fully used LUT-FF pairs	2	249	0%
Number of bonded IOBs	218	218	100%

minimum and after clock as maximum are 6.312 ns and 5.214 ns respectively. The CPU memory usage is 249452 kilobytes. The designed chip is proposed as optimal solution to the proposed system and can be boon for the VLSI industries.

6. References

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