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Device Controller using I^{2}C Bus Protocol by FSM based Verilog code

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Abstract

This paper presents the implementation of the I2C controller on FPGA for interfacing many electric device which is controlled with an on-chip I2C bus interface. The objective of the I2C controller core is to establish and synchronize data transfer between I2C master and many electric device controllers (I2C slave). The design of the I2C controller is accomplished in the form of Finite State Machine (FSM) using Verilog hardware description language and implementation is performed on the digital development platform with FPGA from EDAplayground. The working of the I2C controller is validated through in the most widely used digital waveform known as EPwave signals across its input channels at a time. After the successful acquisition of data from I2c master, the FPGA sends this digital data to electric devices via serial interface. The online portal EDAplaygound is used for monitoring and analysis of data transfer between master and slave.

I. INTRODUCTION

I2C combines the best features of SPI and UARTs. With I2C, it can be connected many multiple slaves to a single master (like SPI) and can have multiple masters controlling single, or multiple slaves. This is really useful when you want to have more than one microcontroller logging data to a multi sensor and actuators. The devices connected to the I2C bus are categorized as either masters or slaves. At any instant of time only a single master stays active on the I2C bus. It controls the SCL clock line and decides what operation is to be done on the SDA data line.

SDA (Serial Data) – The line for the master and slave to send and receive data.

SCL (Serial Clock) – The line that carries the clock signal.

All the devices that respond to instructions from this master device are slaves. For differentiating between multiple slave devices connected to the

Same I2C bus, each slave device is physically assigned a permanent 7-bit address.

In this paper it is been considered that a light control system, audio control system, security control system and the relay control system is been considered as some of the electrical and electronic device which is been controlled and it is to be expected to be the output of the system.

A lighting control system is an intelligent network based lighting control solution that incorporates communication between various system inputs and outputs related to lighting control with the use of one or more central computing devices. Lighting control systems are

widely used on both indoor and outdoor lighting of industrial. Lighting control systems serve to provide the right amount of light where and when it is needed. Lighting control systems are employed to maximize the energy savings from the lighting system. Lighting control systems are often referred to under the term Smart Lighting.

An audio control system is alert the employee who are working in the industry so that the emergency announcement or any voice communication which is required will be communicated to the employee by default as a predefined the audio will make an alert.

Security control system which also been considered an important in the smart of electronic device control system because of any system which as a security will be seen as a safe to use and avoid most of the danger and hence it is the most important to have a security in a system.

Relay control system is required to control any electrical system like motor, valve of fluid, high transmission power supply etc. so in industry the relay control is required.

II. I^2C Protocol

1. The master sends the start condition to every connected slave by switching the SDA line from a high voltage level to a low voltage level before switching the SCL line from high to low.
2. The master sends each slave the 7 or 10 bit address of the slave it wants to communicate with, along with the read/write bit.
3. Each slave compares the address sent from the master to its own address. If the address matches, the slave returns an ACK bit by pulling the SDA line low for one bit. If the address from the master does not match the slave's own address, the slave leaves the SDA line high.
4. The master sends or receives the data frame.
5. After each data frame has been transferred, the receiving device returns another ACK bit to the sender to acknowledge successful receipt of the frame.
6. To stop the data transmission, the master sends a stop condition to the slave by switching SCL high before switching SDA high.

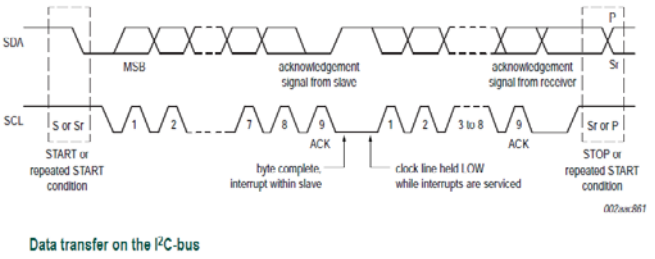

Fig 2.3: I2C data transfer bit allocation

III. Device Controller

In this paper there are considered the four electrical and electronic devices they are light control, audio control, security control and relay control. In which this are selected as the most required devices for the smooth and optimum operation in the industry.

These devices are based on The major advantage of a power saving, industry security machine interrupt for high standard operation to avoid the failure in the production where lighting control system controls the conventional manual switching is the ability to control groups of lights from a single user interface device. This ability to control multiple light sources from a user device allows complex lighting scenes to be created. A room may have multiple scenes pre-set, each one created for different activities in the room. A major benefit of lighting control systems is reduced energy consumption. Longer lamp life is also gained when dimming and switching off lights when not in use. Wireless lighting control systems provide additional benefits including reduced installation costs and increased flexibility over where turns off and sensors may be placed.

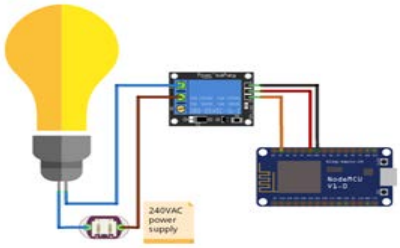

Fig: Automatic Light Controller

Audio control system is controlled the pre-defined audio which is automation which involved in automatic announcement to the employee so that it will prevent in the machine failure as well as the safe and secure for the operator will avoid the accident to the operator. Security controls exist to reduce or mitigate the risk to those assets. It include any type of policy, procedure, technique, method, solution, plan, and action to help accomplish that goal. Recognizable examples include firewalls, surveillance systems, and antivirus system. Relay control is in essence, a switch that is controlled by electrical current. A control relay is an electrical component that opens or closes a switch in order to allow current to flow through a conducting coil, with the coil not coming into direct contact with the switch.

IV. Proposed Architecture

Devices control to be done using the I2C protocol where there will be the 7 bit address in the I2C and that should match to I2C slave where slave is the Devices control module, once the match of the address is correct, then control of the Devices control module can be done.

In this project initially the seven bit address should match with slave address and read or write signal should be low, so it understands that data is writing, and in this it not reading anything or reading is disabled then in the 8 bit of data the first two bit(1,2bit) is light selection on four lights, next two bit(3,4bit) is audio control, next two bit(5,6bit) is security control bit and last two bits(7,8bit) is for relay control system hence the total 8bits are equally shared for four different electrical and electronic devices.

Once all these signals are matched the action of different devices control module, it will be taken of clock signal, reset signal and other sensor input will be given to the respective device module and then respective output action will be seen.

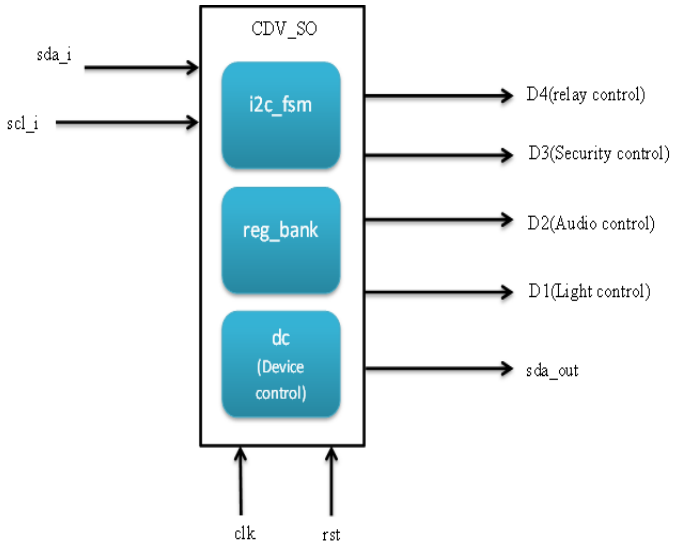

Fig: Design top module

In the above pin diagram it is seen that only two input that is SDA and SCL for this two lines the data is been received to the top module as a I2C concept from this module there are many SOC like I2C, register bank and device controller will be present. Over all from this top module which is of two input and four output.

The flow of data is initially to the I2C part there it will match the address, read/write, acknowledgment, data and start/stop will be received from microcontroller and convert to parallel data and it will be stored in register bank then gives the output.

V. SoC Design Details I^2C

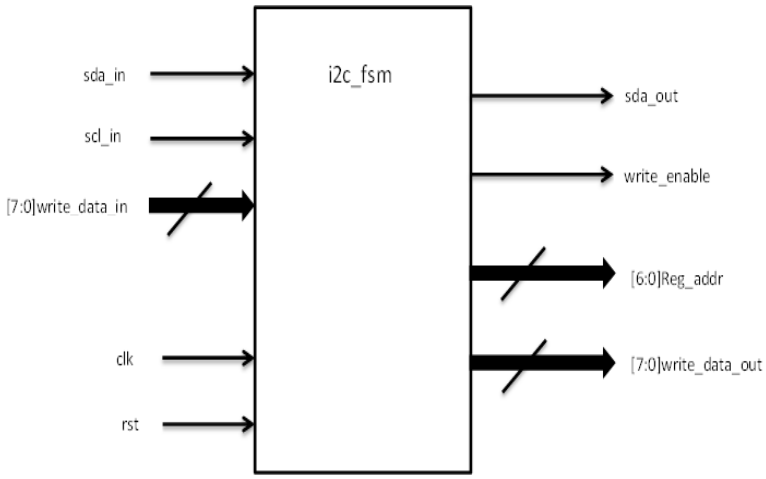

Fig 5.2: Design I^2C protocol

I2C is the serial communication protocol so the data is transferred bit by bit along a single wire. Only two wire are connected between the slave and the master where that is serial data line and the other is serial clock line based on the clock pulse at the time of the data will considered and taken as the input for communication.

Register bank

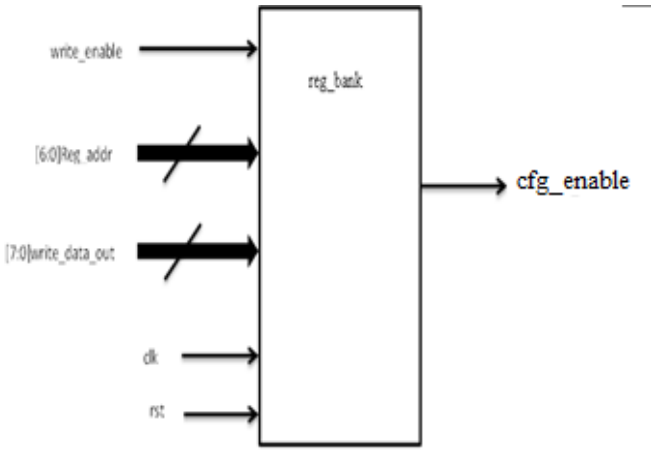

Fig 5.1: Design of register bank

The register bank is to store the data which is sent serially to the top module through the SDA data input and each of the data like address, read/write, will be converted to the parallel data and it will be stored in the register bank. The data stored will be analysed and gives the output as the data which enable to the automatic room light control module.

Device Controller

The Device controller is taken as an application for the I2C protocol where the I2C master send the data and slave will be receive the data and that is in the form of serial data by the use of register bank the data will be converted to the parallel data by the analysis of received data the top module will control the configure enable signal through that the controller will be enabled. Basically it controls the 4 devices.

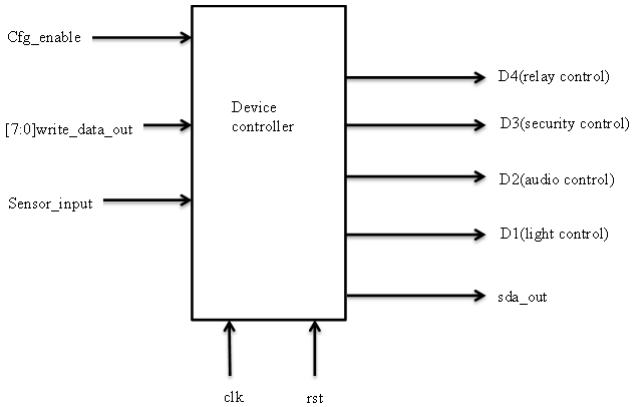

Fig 5.3: Design of device controller module

VI. Result and decision

In the simulation result we observe that initially all devices are off and soon after the address and acknowledgement for that the address is correct and first two bit is dependent to the

selection based on that the respective light are turned on, there is a inbuilt calculation for 2 bit different light can be turned on it activate the light control, in the same way all four device can be activated at the same time and since each carry the 2 bit of massage data it can be operated in the four different ways or it can be used for a bit complex so misbehave of devicewill be avoided.

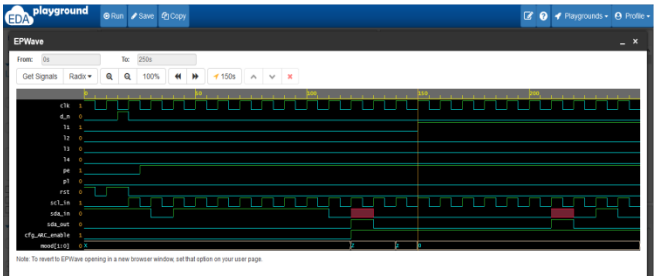

Fig: Turning ON the device 1

Fig: Turning ON device 2

Fig: All device are OFF

VII. Conclusion

The I2C, data is transferred as a message. That Message is broken up into frames of data. Each message has an address frame that contains the binary address of the slave, and one or more data frames that contain the data being transmitted. The message also includes start and stop conditions, read/write bits, and ACK/NACK bits between each data frame that are considered and respective of the device will be controlled based on the massage received.

In this paper it has been designed that a four devices are controlled through I2C bus communication protocol using FSM based Verilog code where the I2C protocol is been set as design as Verilog code and the I2C master as a testbench then for the I2C slave has a register bank is designed to store the received data and for that the device controller is connected so the stored data is given to the device controller and hence the change in I2C master data will change in the operation of different devices ON and OFF which is been controlled.

REFERENCES

[1] UM10204, I2C-bus specification and user manual

[2]https://en.wikipedia.org/wiki/Lighting_control_system

[3]https://www.electronicshub.org/basics-i2c-communication/

[4]http://www.latticesemi.com/products/designsoftwareandip/intellectualproperty/ipcore/ipcores04/i2cmaster

[5]http://electrosofts.com/verilog/fsm.html

[6]https://www.tutorialspoint.com/vlsi_design/vlsi_design_verilog_introduction.htm

[7] The I2C-bus specification, version 2.1,januaray 2000.

[8] Philips Semiconductor “I2C Bus Specification” version2.1, January2000.

[9] I2C specification and User Manual by NXP.

[10] NXP Semiconductors, “I2C Bus Specifications”, April 2014.

BIOGRAPHIES

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