In this paper we propose a method to test a device driver even before the fully functional virtual platform is available for testing. We setup an Intel modem baseband chip build environment and using socket programming test the SystemC model of I2C. SystemC model gives the same behavior as the hardware. All the target test cases are directly executed on the SystemC model. This speeds up the driver development process and maximum possible verification of driver is done even before the hardware is ready. I2C is a multi-master, multi-slave, single-ended serial communication bus, it is used for connecting peripherals to processors in embedded systems. Socket programming is used for the communication between the I2C driver and the SystemC model. SystemC is a set of C++ classes and macros which are used for hardware simulation.

The features of I2C are:
- All the devices connected to the bus have unique addresses and a simple master/slave relationship always exits; master can operate as master transmitter or as master receiver.
- Only two lines SDA and SCL are required.
- I2C bus has collision detection and arbitration logic to prevent data corruption if two or more devices initiate data transfer simultaneously.
- It supports 3 modes of operation: Standard mode with data transfer up to 100 kbit/s, Fast mode with data transfer up to 400 kbit/s and High-speed mode with data transfer up to 3.4 Mbit/s.
- To preserve data integrity on chip filtering is done to reject the spikes on data bus.
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**I2C Bus Specifications**
The I2C bus is built around a two-wire serial bus, serial data (SDA) and serial clock (SCL), these two lines carry information between the devices connected to the bus. Each device connected to I2C is recognized by a unique address and can operate in master mode or in slave mode [3]. Master initiates a transfer and generates the clock for the same and the device addressed by the master is called as slave. If two or more devices tries to transmit data at the same time then the winning master is recognized using arbitration process.

**A SystemC model of I2C is developed to test the functionality of the I2C driver software used in the smart phone. This SystemC model replaces the device emulator which was used previously for host testing. The communication between the SystemC model of I2C and test cases is done using socket programming.**

The important specifications of I2C bus are described in Section II and specifications of socket programming are described in Section III. The process methodology is described in Section IV and simulation results are described in section V. Section VI contains conclusion and future scope.

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The SDA and SCL lines are connected to a positive voltage supply using pull-up resistors. The bus is free when SCL and SDA lines are ‘high’. Master generates a start and stop condition during data transfer as shown in the fig 2.

**Figure 2:** The start and stop condition.

- **Start condition:** A high to low transition on SDA when SCL remain high, represented by ‘S’ in fig 2.
- **Stop condition:** A low to high transition on SDA when SCL is high, represented by ‘P’ in Fig 2.
- **Data on SDA is valid only if SCL is high.** B1, B2…Bn represents the valid bits.
- **Data Transfer**
  - Data is transferred after the start condition, the transmission is byte oriented and every data is placed on SDA line. Master frees the SDA line after transmission. The complete data transfer is shown in Fig3.

**Figure 3:** The complete data transfer operation.

After start condition address of the slave is sent and after slave address RnW bit is sent which determines the direction of data. Slave send an acknowledge bit ‘A’ to master, after this data is sent or received depending upon the RnW bit. If RnW bit is 1 then master reads data from slave and if 0 then master writes data to the slave.

- **Arbitration**
  - When two or more masters may generate a defined start condition simultaneously then arbitration logic is used to allow multi master mode. Arbitration takes place on SDA line when SCL line is high. When a master transmits a low level and another transmits a high level then due to wired AND functionality low level dominates the high level, as a result device that was transmitting a high level switches off.

**SOCKET PROGRAMMING**

Sockets are used for inter-process communication across a computer network. Network sockets are used and controlled by socket application program interface (API). Berkeley sockets standard is used in most of the internet sockets [4]. A socket address is formed by combining IP address and port number. Socket address is used to deliver the packet to the appropriate application process or thread.

- **Types of sockets**
  - Datagram socket: It is connectionless network socket. Packet using datagram socket are individually addressed and routed.
  - Stream socket: It is a connection oriented network socket. The data is received in a sequence. It uses a well-defined mechanism for creating and destroying connection. It is implemented on TCP so that application can run on networks using TCP/IP protocol [5].
  - Raw socket: It is an internet socket. It allows direct sending and receiving of data without any protocol specific transport layer formatting.

**Connection of the Client / Server system**

**process methodology**

A device emulator is used for host testing, but it does not support full functionality of the device driver. In the proposed method we replace the device emulator with the SystemC model. SystemC model behaves as the server and client socket is integrated with the source code of the driver. Using SystemC in place of device emulator reduces the difference between host and target test cases.

Architectural block diagram of the implemented communication between the SystemC model of I2C and test cases is shown in the Fig.5.
The steps for making connection between SystemC model and test cases are:

- The first step is to call the socket() function at the server, specifying the type of communication protocol (TCP based on IPv4), and call listen() function to listen for an incoming connection.
  - Socket type - Stream socket.
  - IP address "127.0.0.1"
  - Port number "1234"
- A socket is created at the client side and connect() function is called to establish a connection with a TCP server.
- Accept() function is called at the server side to accept the pending connections on socket. It then creates and returns a handle to the new socket.
- A thread is created at the client side to continuously receive data simultaneously with the main thread. An infinite for() loop is used to receive data.
- I2C driver initiates write operation using i2c_set_reg() function, it provides the value and the address of the memory location.
- tcpip_bridge_write() function uses the information provided in the previous step to write value to the specified memory location.
- An echo of the message received at the server, is sent back to the client, this echo message is received by the client using receive() function. The message is compared with "Read", "Write" and "irq", and the write_event is signaled.
- I2C driver initiates read operation using i2c_set_reg() function, it provides the address of the memory location from where value is to be read.
- tcpip_bridge_read() function uses the information provided in the previous step to read value from the specified memory location.
- An echo of the message received at server, is sent back to the client, this echo message is received by the client using receive() function. The message is compared with "Read", "Write" and "irq", and the read_event is signaled.
- An interrupt may occur at the server side any time, this is received at the client side and respective interrupt service routine is run.

RESULTS

Fig. 7 shows the server socket is bind to the IP address ‘127.0.0.1’ and port number ‘1234’. The server socket is waiting for a connection request from the client side.
I2C master in future SystemC model I2C slave can be implemented and test cases for I2C slave can be executed on it. This method can be used by other device drivers for testing purpose.

REFERENCES


