ISSN (Online) 2394-6849

International Journal of Engineering Research in Electronics and Communication Engineering (IJERECE)
Vol 5, Issue 6, June 2018

System validation of Proximity Integrated Circuit Card using FPGA

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***Abstract*— Near field communication is being used in many day to day applications likes e- passports, ticketing system, access control, loyalty cards, payments etc. Passive proximity integrated circuit card and proximity coupling device are used with the principle of inductive coupling. This is a wireless communication with the carrier frequency of 13.56MHz within the scope of 10cm. An FPGA platform is implemented to perform the digital system validation. Validation is performed to make sure that it is compliance with ISO/IEC 14443 protocol with Type A communication. Some of functional Test methods used are from ISO/IEC 10373 – Part 6 protocol. The validation is performed for multiple process corners, all protocol commands, and antenna classes varying from class 1 till class 6, baud rate up to 848kbps, extreme temperature conditions, and multiple iterations for lowest achievable field strength. The following is performed to ensure the best fit for operating field, data rate and chip area.**

Index Terms— near field communication, RF ID, FPGA , proximity cards.

I. INTRODUCTION

The Near field communication (NFC) on Very large scale integrated (VLSI) chips has been an existing, yet a fast-growing field which gives lot of encouragement to improvement in terms of power, cost, area and performance requirement. These involve communication between Proximity coupling devices (PCD) and Proximity Integrated circuit card. The transfer of power and data is through the power supplied by the reader to the card which doesn't involve batteries. Before data gets exchanged between a reader (Proximity Coupling Device) and a card (Proximity integrated circuit card), the card must be properly selected. This process of card activation (card selection) is described in the International Organization for Standardization (ISO)/ International Electro Technical Commission(IEC) 14443 standard for contactless proximity systems. It is very important select a correct PICC out of many other cards near the reader field. The complexity has increased due to the drastic increase in contactless applications.

ISO/ IEC 14443 is a protocol for Contactless smart cards for distance of 10cm. This ISO standard was developed to describe in detail as to how the applications need to process them. PICC has an VLSI chip and it is plugged with an antenna. This standard describes: (1) the physical properties (2) the initialization and power transfer, (3) anti-collision, (4) transmission protocol. In this paper, validation of PICC is performed using Field programmable gate arrays (FPGA) based setup. Type A communication protocol is being used for the carrier frequency of 13.56MHz. System validation for PICC is performed using ISO/IEC 10373- part 6 test methods.
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II. LITERATURE SURVEY

Passive contactless Proximity Integrated Circuit Card (PICC) consist in an integrated circuit (the chip), and an antenna connected to the chip. It communicates with a reader device by backscattering the power provided by the reader. These cards do not involve batteries, and are supplied directly by the reader [1]. This technology has experienced a strong development recently, and especially cards communicating with readers by modulating a carrier of 13.56MHz.

Test platform (figure 1) architecture can be discomposed as follows: first, a transmitter has been implemented to communicate with a PICC or a PCD. Then, a receiver that adopts a dual function has been developed. This receiver can demodulate and understand the NFC devices frames, but it is also able to record and analyze the parts of interest in a communication to assess NFC products compliancy with ISO standards.

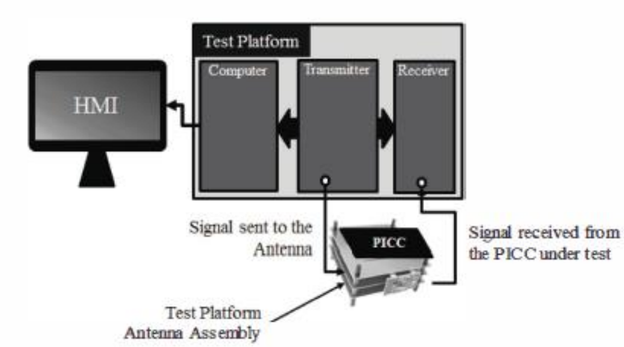

Fig. 1 Test Platform

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The signals are sent to the PICC card through the antenna assembly, as presented in [5]. The response from the PICC card is then received by the same antenna assembly, digitalized by the receiver's Analog to digital converter (ADC), and analyzed by the test platform. The Human Machine Interface (HMI) of the test platform displays the test results. [5] presents the various kinds of tests that need to be realized. Finally, the HMI allows the user to select which test one wants to conduct.

To achieve a communication, HF tag platform implements the layer 3 and 4 of the 14443- Type A standard . Later, an authentication protocol must be developed for the security of the communication. After supplying the tag emulation platform, either a Request command or a Wake Up command must be issued to the tag. When a Acknowledgement to RequestA (ATQA) is received by the reader, the detection process completes and the anti-collision process starts. The anti-collision process serves two main purposes. 1. For the reader to place only a single tag into an activated state if multiple tags are placed in the proximity . 2. to acquire the Unique IDentifier (UID) and Select AcKnowledge (SAK) of the tag. The tag is in an activated state, After the SAK response is received. To complete the tag selection, reader must send a Request for Answer To Select (RATS) command. The tag is fully selected, If a reply Acknowledgement to select (ATS) is received and ready to exchange data with the reader module. The authentication phase is implemented in this phase.

There are many journals about RFID transceiver structures [9] [10] [11]. But it is important to design a transceiver test board using discrete mechanisms to implementation as a chip level. Beyond a computer simulation, merging tests between digital baseband and analog front-end helps designing transceiver SoC more consistently and firmly. There is also an introduction to standards for 13.56MHz RFID system and required specifications in paper [12],. From these processes, 13.56MHz RFID transceiver for multi standard reader is proposed. After the trials of the test board, designed transceiver circuit is fabricated into a chip using 0.18um CMOS technology.

III. METHODOLOGY USED FOR THE VALIDATION OF PICC

To measure the quality of NFC products, it is essential to realize tests and evaluate the functionality. Numerical or functional tests aim at evaluating the state machine implemented in a firmware loaded onto PICC chip, or in the PCD controller. The analog tests aim at assessing the quality of the signals during a communication in terms of modulation index, rising time, overshoots, etc. NFC test platform must be able to realize these kinds of tests. Thus, an FPGA is used as an emulator which is able to communicate with card and decode the response for the further analysis.

The architecture can be discomposed as follows: first, a transmitter has been implemented to communicate with a PICC or a PCD. The receiver can demodulate and understand the frames sent by NFC devices, but it is also able to record and analyze the communication to assess NFC products compliancy with ISO standards. The computer analyzes data from the receiver and sends signals to the transmitter. The signals are sent to the PICC card through the antenna assembly. The response from the PICC card is then received by the same antenna assembly, digitalized by the receiver's ADC, and analyzed by the test platform. ISO 10373- Part 6 provides different tests to be conducted. HMI allows the user to select which test one wants to conduct and display the results.

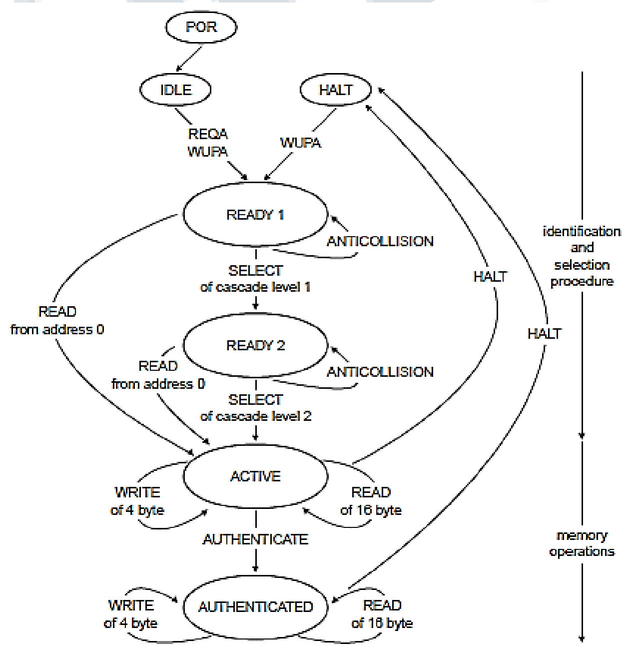

Fig 2. PICC state transition diagram

At the transmitter, the signal characteristics like rising and falling times, overshoot, modulation index and frames like REQA, SELECT etc. sent to the PICC under test depending on the test that must be realized, and consists of frames with predefined signal characteristics. Commands from transmitter (PCD) has Miller coded data whereas response sent from

PICC has load modulated data with Manchester encoding and ASK modulation. The state transitions diagram of PICC is shown in the figure 2.

Following tests performed for PICC as a part of system validation . ISO/IEC 10373- Tests includes 1.Card reset, 2.startup time test, 3.PICC reception tests for of multiple baud rates and patterns, 4.Load modulation amplitude or PICC transmission test, 5.Alternating magnetic field test and 6.Frame delay time between PCD and PICC.

System parameters or test conditions are as per the table 1.

IV. RESULTS AND DISCUSSION

Figure 3 shoes Digital oscilloscope for the REQA command from PCD and ATQA from PICC. Forward Miller modified command from PCD, Frame delay time and Backward Manchester encoded response from PICC. FDT time is characterized by unmodulated carrier.

Minimum field strength condition 1.5A/m validated for different wave shapes of the miller pause. Baud rate -106kbs, Temp at 25Ç and nominal corner sample is shown in the figure 4.

Table I. Parameters for system validation

Parameters	Values
Process corners	Slow, fast and nominal
Temperature	25˚C , 80˚C and -30˚C
Minimum field strength	1.5A/m to 7A/m
Antenna Class	Class1-6.
Resonant frequency	13.56MHz
Data rate	fc/128 , fc/64 , fc/32 and fc/16.
ISO/IEC 14443 command	All
PICC state transitions	All
No. of iterations	3-10

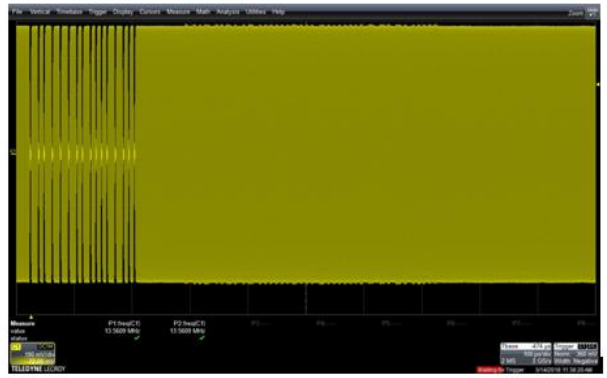

Fig 3. Oscilloscope result for REQA command & ATQA

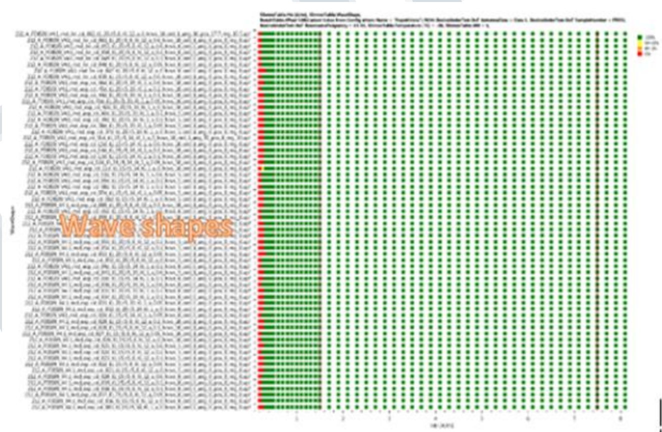

Fig 4 . PICC Reception test results

CONCLUSION

With the development of NFC products, evaluation and optimization of chip is very much essential even during the validation phase. To achieve the proper functionality with compliance to ISO 14443 it is essential to have a test bench performing the functional validation. DUT to operate at different supply voltage, data rate, temperature range, wave shapes it is necessary to perform the system validation to find the best fit out of all. In this method, PICC is tested on an FPGA platform for the above system parameters with ISO 10373- Part 6 test methods to receive and respond to PCD requests.

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Vol 5, Issue 6, June 2018

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