

Wave5G-PHY Automation

Swarna Somayaji S¹, Prashanth G S²

¹Student, Department of ECE, JNNCE, Shivamogga, Karnataka, India

²Assistant Professor, Department of ECE, JNNCE, Shivamogga, Karnataka, India

Abstract - 5G network refers to fifth mobile generation network communication. 5 G Mobile communications infrastructure will create a network interconnected by everything, a completely mobile and wired world in which everything becomes interconnected with people and device-connected objects. The 5 G mobile communications employ the technique of multiplexing the Orthogonal Frequency Division (OFDM), which transmits large amounts of digital data over a radio wave. The technology works by splitting the radio signal into several smaller sub-signals, which are then simultaneously transmitted to the receiver at different frequencies. But depending on the geographical changes and user load, the physical layer (PHY layer) keeps changing the configurations. To test PHY layer functionality in all those in house scenarios, it is important to have test suite architecture to test those configurations in those specific scenarios. The work on automating the physical layer configurations for the wave 5 G was carried out in this paper. The automation tool is used to model and check the configurations in the PHY layer. The automation tool can check the configurations, analyze them and give the result. This will reduce the time and give an accurate result of all configurations as compared to the set of configurations being run manually.

Key Words: PHY layer, Automation, PBCH, Template Configuration, IQ samples

1. INTRODUCTION

Wireless communication has been one of the necessary technologies in the last few days. Wireless communication is a way to transmit information, without any physical medium, from one point to another. To have a wireless connection, the host-receiver configuration must be efficient for the proper transmission to occur. Wireless communication is widely used on cellphone or communication devices. 5G wireless technology is designed to deliver higher data peak rates of multi-Gbps, ultra-low latency, improved reliability, vast network power, improved availability and a more reliable customer experience. Improvements in efficiency and performance allow new user interfaces and connect newer industries [1]. 5G includes orthogonal frequency division multiplexing (OFDM) packet switched wireless systems with large area coverage. At millimeter waves it offers high throughput across a frequency range from 30GHz to 300GHz. It also permits data rates of up to 20Mbps over a 2 km distance [2].

Radio access, data speeds, bandwidth and switching schemes are the four key aspects differentiating the cellular generation. Greater coverage and high data speed is the biggest distinction between current generation and planned 5G network. One of the most important problems is the physical lack of radio frequency (RF) spectra reserved for cellular communications [3].

The 5G technology portrays five different layers of network protocol stacks, derived from the OSI model's 7 layers. The Physical Layer channel modules are designed based on the standard specification which is described using the specification series Release-15 and Release-16 3GPP. Various downlink and uplink channels are built using those specifications. Physical Broadcast Channel [PBCH], Physical Downlink Shared Channel [PDSCH], and Physical Downlink Control Channel [PDCCH] are the distinct downlink channels built. Physical Uplink Shared Channel [PUSCH] and Physical Uplink Control Channel [PUCCH] are the various modules in the uplink channels. The main function of physical channel modules is to transport scheduling data of different types. It should be capable of handling resource scheduling in DL, power controlling guidance in UL, resource approval in UL, paging or indication of system information [4].

Connectivity between gNodeB and user equipment (UE) must be correctly configured, which is achieved by configuring the PHY layer. Depending on geographical shift and user load the PHY layer keeps changing. To test PHY layer output in all those in house scenarios, it is important to have test suite architecture to test those configurations in those specific scenarios. This work aims to create an automation framework that tests all set of configurations and gives each set an individual result. This automation is geared towards providing connectivity between the test suites and the physical layer of wave 5G. It will check all possible configurations provided by the configuration of the prototype and the result analysis with regard to the generated output as it passes or fails.

2. BLOCK DIAGRAM

Fig 1 displays the block diagram of the work. The template configuration consists of all the specified parameter values for the configurations. The template configuration will consist of the PHY execution configuration format. Those test cases are sent via TCP connection to the PHY layer. The test framework will act as client and the server will act as the PHY layer. The output generated from PHY layer is a log file.

This consists of the IQ samples generated from the set of inputs for the given test case. The log file generated is fed into matlab exe which will decode the IQ samples for further analysis. The exe will also generate a set of plots and give the output which has the decoded parameters to a text file. This text file is provided to the test framework that processes the output and compares with the input test cases and provides the user with the result.

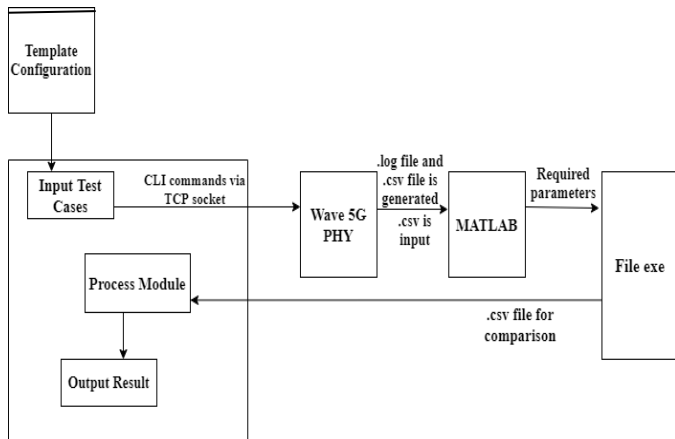


Fig 1: Block diagram of the automation framework

3. IMPLEMENTATION PROCEDURE

This section presents the necessary steps to be followed to implement the creation of automation framework. There are basically four phases to be followed one by one.

3.1 Template Configuration

Template configuration is used for testing which tests an application with multiple combinations of software and hardware to determine the optimum configurations that the system can operate without any flaws or bugs. The prototype configuration is given to a test case, where several software and hardware configuration combinations are made, and these combinations must be used to test the application under test.

The template configuration in this framework consists of the format for configuring execution of PHY layer. This template configuration is given for further processing of the input test cases.

3.2 PHY Testing

The input test cases are a.txt file placed in a folder in that framework. Each test case folder has all the contents of input files. The input test cases are built on CLI commands and sent via TCP link to wave PHY layer. The test framework here acts as a client, and PHY layer acts as a server for connection establishment. The PHY layer produces the output as a log file. The log file is composed of IQ samples given to the MATLAB exe for further processing.

A TCP connection is one endpoint of a two-way link between two programs running on the network. The server is

connected to a port number so that the TCP layer can define the application it is expected to send data to. A server creates a socket, connects the socket to an IP address and port number and listens to connections coming in. When a client connects to the server a new client communication socket (TCP only) is formed.

In this case, a connection between the test framework, acting as a client and PHY layer, acting as a server is established. After sending the test framework commands, a log file is generated as the output that is the test result.

3.3 MATLAB Exe

The matlab exe is used to process the results of the decoded configurations produced from the PHY layer and to analyze the results. The matlab will take all the processing parameters decoded, where different plots are generated and a matlab txt file. The created txt file will contain all the parameters necessary for test case analysis. A file exe is given the created txt file which will convert it into a.csv file for easy comparisons to be made. The matlab decodes the samples of the IQ and produces a text file with the few parameters necessary for analysis. Matlab exe will also generate some plots as the results, based on the IQ samples.

3.4 Analysis

Here the comparison of configurations is done by sending the generated file to the test framework. The comparison is made against the matlab-generated file and the input test configurations. The output is given for every single parameter whether it is a Pass / Fail. It also provides a cumulative of all the parameters as each test result.

The cumulative result will give a pass if all parameter comparison passes, if one comparison fails, then the cumulative test will fail. The flowchart of the framework is depicted in Fig 2.

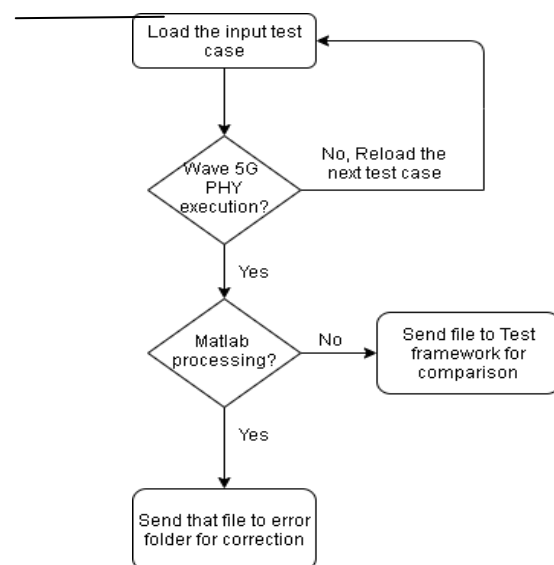


Fig 2: Flowchart illustrating the steps in automation

4. IMPLEMENTATION RESULTS

The various plots generated at the end of testing the configurations are depicted in this section.

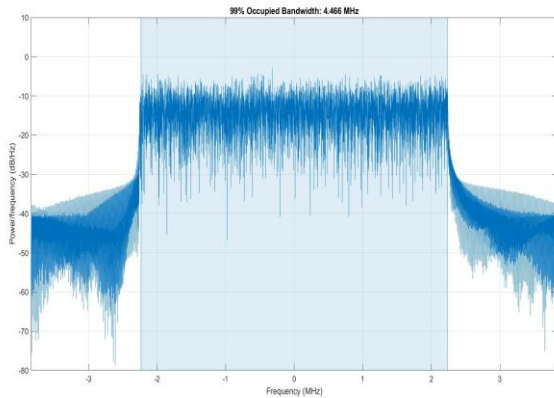


Fig 3: Bandwidth occupancy plot for 5MHz

A measurement of the frequency range at which signal energy spreads, occupied bandwidth can be used to evaluate communication efficiency levels, and to diagnose degrading communications systems. The transmission standard 3GPP, describes OBW as the bandwidth of 99.0 percent of the total integrated signal power, based on the frequency allocated to the channel as shown in Figure 3.

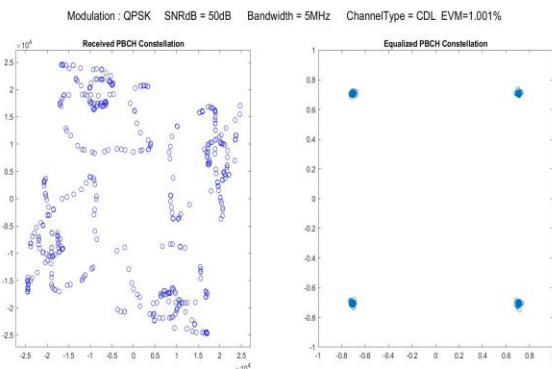


Fig 4: PBCH Constellation plot

The digital representation of modulated signal is called as constellation diagram. The constellation diagram displays all possible symbols that can be expressed as a sequence of points. PBCH is a special platform used for the transmission of MIB information using QPSK modulation scheme. MIB information transmits information regarding physical cell ID and the antenna ports which are used. Fig 4 represents the constellation diagram of PBCH.

The control information regarding the data to be transmitted on the current sub-frame and the information on the tools that UE uses for uplink information is carried by PDDCH channel. DCI (Downlink Control Information) that includes resource allocations for an UE is also carried by this channel.

In a single sub frame, eNodeB can transmit many DCI's or PDCCH's.

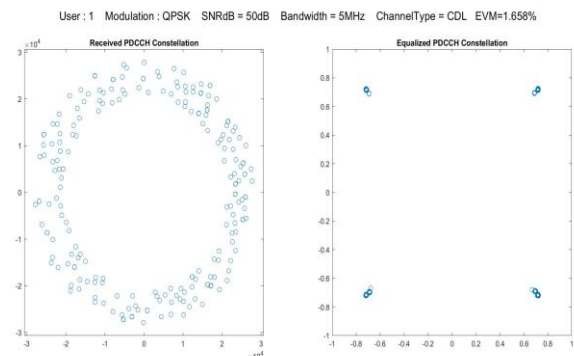


Fig 5: PDCCH Constellation plot

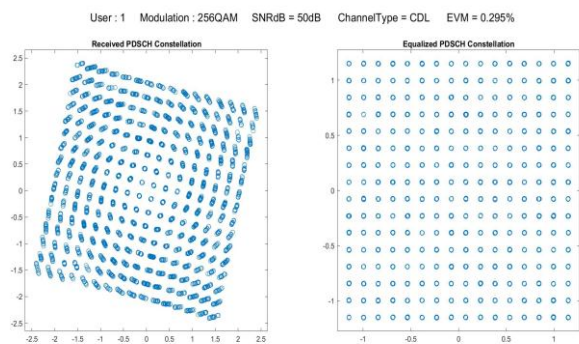


Fig 6: PDSCH Constellation plot

User data information is transmitted through PDSCH channel. This channel will transmit user specific data which is called as the DL Payload. The modulation technique of 256 QAM is used as depicted in Fig 6.

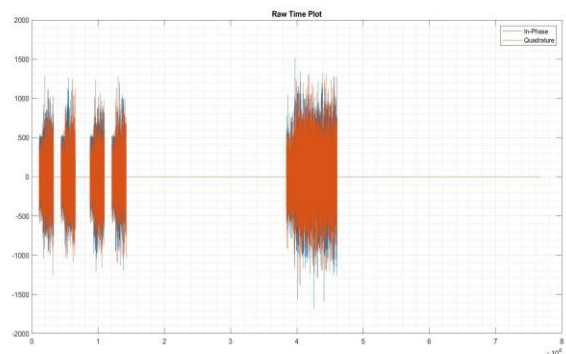


Fig 7: Raw Time plot

The implementation of the time plot where phase and magnitude are plotted is as shown in Fig 7. The red lines indicate in-phase and blue line indicate quadrature phase.

5. CONCLUSIONS AND FUTURE WORK

In this rapid digital era, high-speed data communication and internet services are needed that keep everyone and everything connected, from things to people and business. There has been evolution from 1G to 4G technology to provide high speed data communication. With the launch of 5G technology, improvising and enhancements have been made in the advancement of mobile connectivity. This technology deploys communication in data packets, using orthogonal frequency division multiplexing which provides wide range coverage. By the use of millimeter-wave band, high frequency wireless internet can be supported. Smart antenna technology is incorporated for the communication between the consumer equipment and the eNodeB. In order to provide all the requirements, a stable physical layer module has to be configured. Therefore the PHY layer modules configurations play a significant role.

Configuring these parameters manually is very tedious task and is time consuming. Thus, an automation system is designed to start the configuration process automatically, check them and display the results of each configuration's success or failure. The entire work in this paper is dedicated in the context of automation and research. But the testing was conducted for the in-house condition of the PHY layer, and not on a real-time basis. Thus, the framework can be improved to put in hardware level and implement it in real time scale. The framework was tested and configured for downlink configurations. The uplink automation framework can also be implemented in the same method.

REFERENCES

- [1] D. Choudhary, "5G wireless millimeter wave technology evolution: An overview," IEEE Transactions on Wireless Communications, April 2015
- [2] M. A. M. Albreem, "5G wireless communication systems: Vision and challenges," IEEE Transaction on Wireless Technology, vol. 3, no. 15, 2015.
- [3] X. Chi and L. Yang, "Research on key technology in 5g mobile communication network," IEEE Transaction on Telecommunication, vol. 65, no. 2, 2019.
- [4] D. K. B. S. B Ganesh Kumar and A. Gupta, "Integration and verification of physical layer modules for 5g technology," IEEE Transaction on Electronic Communication and Aerospace Technology, 2019.
- [5] R. O. S. Usmonov Botir Shukurillaevich and Rustamov Umedjon Amrillojonovich, "5g technology evolution," IEEE Transaction on Wireless Communications, vol. 45, no. 18, 2019.

- [6] Sandip Gangakhedkar, Hanwen Cao and J. Eichinger, "Use cases, requirements and challenges of 5g communication for industrial automation," IEEE Transaction on Networked and Controlled Systems, 2018

BIOGRAPHIES

- [1] Swarna Somayaji S has completed B.E in 2018 from JNNCE, Shivamogga. She is presently pursuing MTech in Digital Electronics and Communication Systems in JNNCE, Shivamogga.
- [2] Prashanth G S has completed BE in 2007 from REC, Hulkoti and Mtech in 2013 from JNNCE, Shivamogga. He is currently pursuing PhD in the area of WSN. His areas of interests are communication system and WSN.