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The Design of Downlink Radio Access Point for Radio over Fiber for LTE Applications

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Abstract: The project describes about the design of Radio Access Point for Radio over Fiber for LTE applications. The purpose of this project is to design a circuit which can support a very high data rate and overcome radio frequency congestion, since the user demands are increasing. Another purpose is to create a strong connection within a further distance especially in rural areas. The project is done by analyze the performance of Signal Noise Ratio (SNR) for the RAP in downlink transmission, by making a comparison between the measured data obtained from the factory, and the components inside the software OptiSystem. By analyse the performance of the signal, a good service quality of coverage can be provided to users with a distributed antenna system constructed using optical fiber cable. Perhaps this research will contribute to the improvement of services due to user high demand. Even when many customers use the internet at the same time place, the service can still be maintained.

Keywords: fiber optic, gain, output power, Signal-to-Noise-Ratio (SNR) and s-parameter

1.0 INTRODUCTION

Internet is one of the living basic needs nowadays. It is important as people use it to communicate with others from all over the world. It is also used to find knowledge for assignments, online shopping, or making online business, sharing informations and etc.

As the technology become advanced for every single day, and also the user demands are increasing, it is important to

make a faster connection, within a further distance, so that the user can obtain information, or get everything they need very fast, since time is business nowadays.

The latest technology used in communication is 4G LTE. However recently in Malaysia, there is no accurate frequency for 4G LTE. Furthermore, only certain areas in Klang Valley has the internet coverage. However outside Kuala Lumpur, there is no connection especially in rural areas. Although there is a connection, the signal is not strong enough for the information to be received.

The purpose of this project is to design a circuit which can support a very high data rate and overcome radio frequency congestion, since the user demands are increasing. Another purpose is to create a strong connection within a further distance especially in rural areas.

2.0 RELATED WORKS

Normally in the previous design of the Radio Access Point (RAP), many problems had occurred. The installation of base station is difficult. It requires high cost and high power. Furthermore, there is no coverage in “Dead Zone” areas. It means the RF coverage cannot be reached. Increasing number of users lead to high demand of users to improve services and capacity of mobile networks. Service is down when many consumers use them at the same time and place. [1]

There is also a low speed of data transmission. It is upgrading from UMTS. High attenuation of coaxial cable is another problem faced for the previous design. [1]

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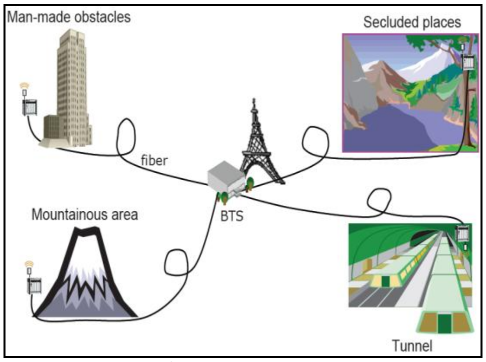

Fig. 1 Optical link for dead zone

In terms of distance limitation, wireless system cannot support long haul connection and need more repeaters and amplifiers to improve the signal quality. Attenuation is another factor that can affect the transmission of the signals. In wireless communication, when the signals transmit through the air, attenuation occurs. Wireless transmission may also be affected by weather and very prone to lighting. [1]

By using fiber optic cables, attenuation can be reduced as it is very thin and covered by many coating layers. Wide bandwidth is another important factor for more information to be transmitted and received.

3.0 THE PROPOSED TECHNIQUE

3.1 Block Diagram

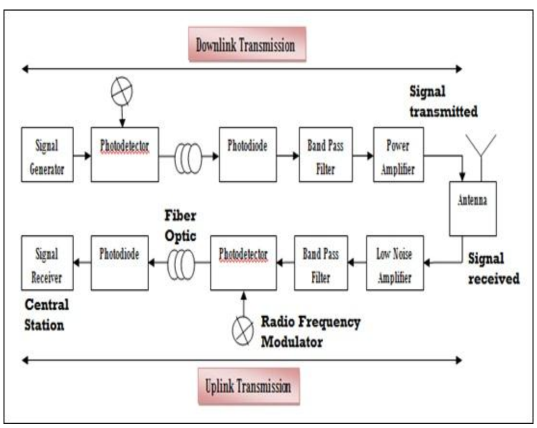

Fig. 2 Radio Access Point Architecture

In Radio Access Point, the transmission of the signal consists of 2 parts, which is downlink transmission and uplink transmission. The downlink transmission starts from a central station to an antenna transmitter. The uplink transmission starts from an antenna receiver back to the central station. However, this paper only focuses on the downlink transmission.

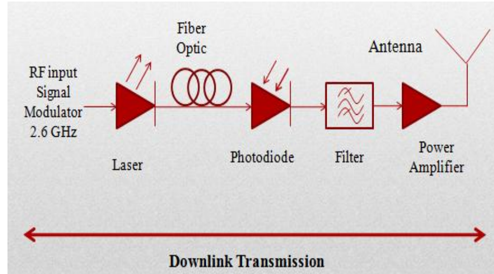

Fig. 3 Block diagram of downlink transmission

For downlink transmission, the signal transmission started from a signal generator. A photo detector converted an electrical signal into a light signal. It is because only light signal can passes through the optical fiber. The light signal then passed through the optical fiber cable through a laser. When the light signal has passed through the optical fiber cable, a photodiode converted back the light signal into the electrical signal.

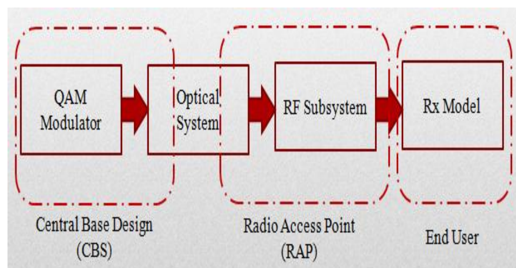

Fig. 4 Downlink Radio over Fiber Architecture

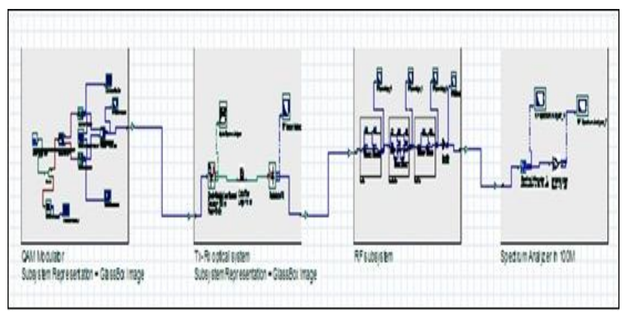
Fig. 5 Downlink Radio over Fiber Architecture in OptiSystem

3.2 Software Used

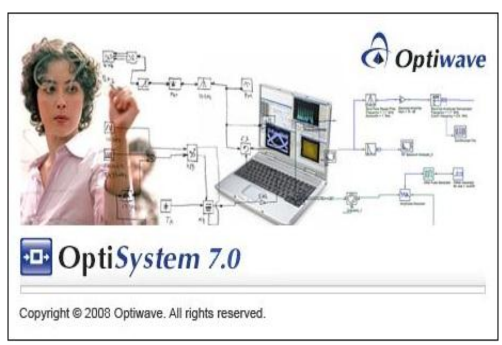

Fig. 6 OptiSystem Software

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The software used for this project is OptiSystem 7.0. This software is used to simulate the circuit and make an analysis to the data obtained from the factory and from the simulation from the software itself. It is better to do the simulation first, since the real cost for the components are too expensive and require a lot of time to produce the real design. If the simulation shows a good result, a telecommunication company (Telco) can buy the prototype and try to implement them in this country. Perhaps the current communication technology can be improved.

The software does the calculation of the data of the components inside the circuit to produce the graph which is the result. Noise is also included inside the graph. Data will be analysed based on Signal-to-Noise-Ratio (SNR).

4.0 DESIGN DEVELOPMENT

4.1 Overall system

This is where the whole system study has started, the Radio Frequency (RF) subsystem. A band pass filter filtered all noise from the signal transmission of optical fiber cable earlier. Low noise amplifiers amplified the filtered signal. A power amplifier amplified the signal at higher amplitude to get more gain or output. An antenna will transmit the signal to areas which will have coverage such as houses, office buildings, cafeteria etc.

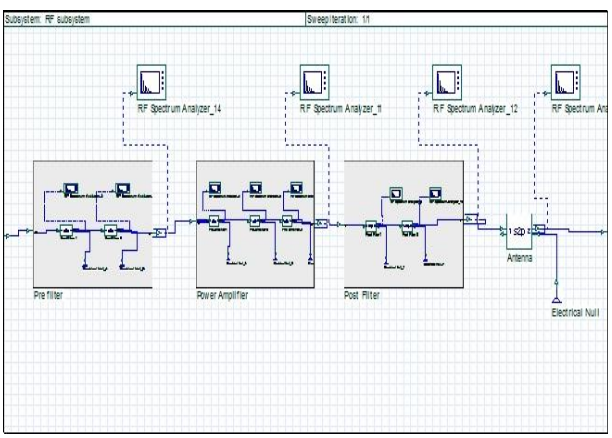

Fig. 7 Measured part of RF Subsystem

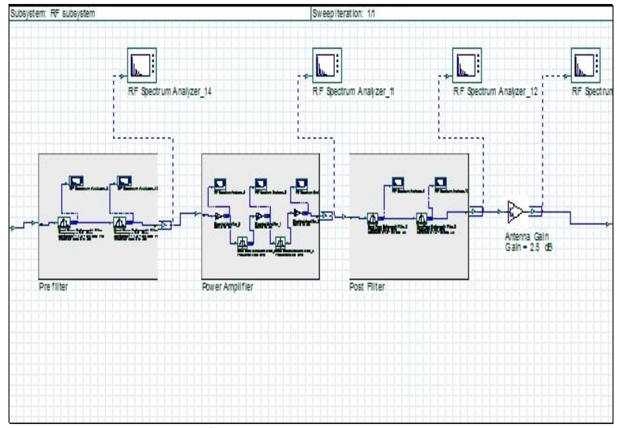

Fig. 8 Simulated part of RF Subsystem

The difference between the 2 designs is the components used. For the measured part of RF subsystem, the components used are based on factory data. It means the factory has programmed the components. The data is all set in s2 parameter file. For the simulated part of RF subsystem, the components inside the OptiSystem had their own properties, and free from any interference from the environment.

In simulated part, the gain for each component had been set, according to the referred data sheets and journal. For pre-filter and post-filter, the gain is 2 dB. For pre-amplifier, the gain set is 17 dB. 23 dB has been set for power amplifier, and 2.5 dB for antenna.

5.0 RESULTS AND DISCUSSION

5.1 Measured Results

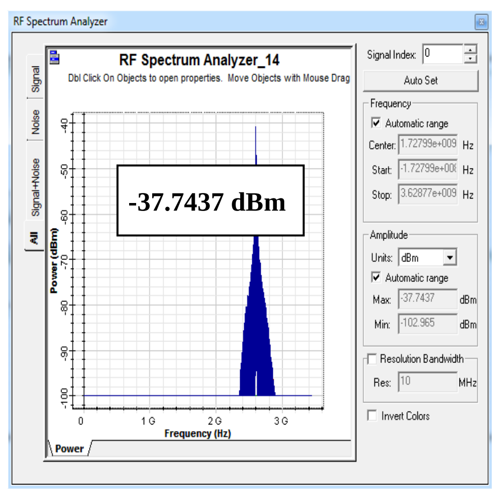

Fig. 9 Measured total pre-filter in 50 km

Measured total pre-filter output power at -37.7437 dBm is higher than simulated total pre-filter output power at -38.9237 dBm. The conditions of simulated components are perfect and free from noise explained the lower gain of

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pre-filter 1. Furthermore, the signal transmission comes directly from the optical fiber cable.

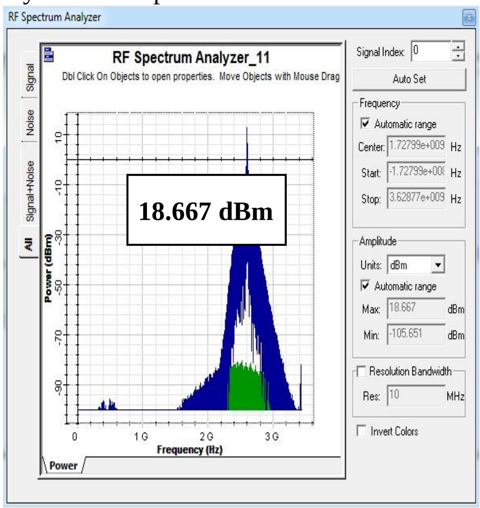

Fig. 10 Measured total amplifier in 50 km

Measured total amplifier output power at 18.667 dBm is higher than simulated total amplifier output power at 16.7269 dBm. Low noise amplifier is used since a lot of noise has been removed by the pre-filter circuit. Signal will be amplified at this stage. Power amplifier is used to increase the gain of the signal at the highest gain as possible.

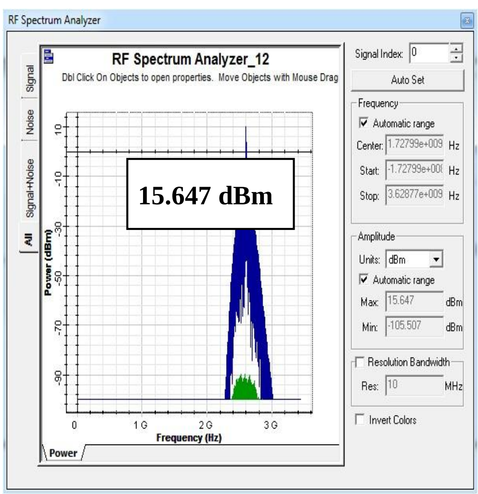

Fig. 11 Measured total post-filter in 50 km

Measured total post-filter output power at 15.647 dBm is higher than simulated total post-filter output power at 12.5269 dBm. Since the signal transmission comes directly from the power amplifier, it is important to use the post-filter for further filtration of the noise caused by the power amplifier. It is because the gain and noise of the signal from power amplifier are at the highest.

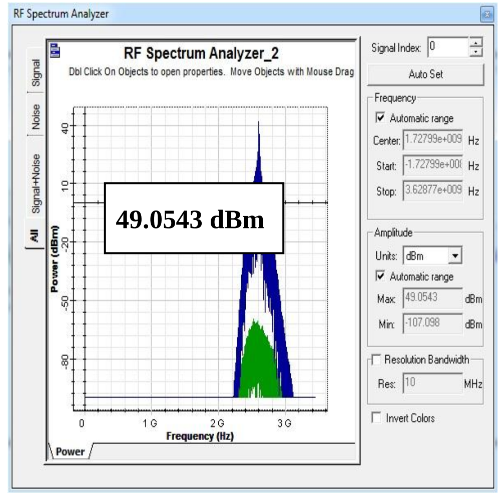

Fig. 12 Measured antenna in 50 km

Measured transmitter antenna output power at 49.0543 dBm is higher than simulated transmitter antenna output power at 15.1519 dBm. As a result, the transmitter antenna manages to transmit signal at the highest power within the range of 100m.

5.2 Simulated Results

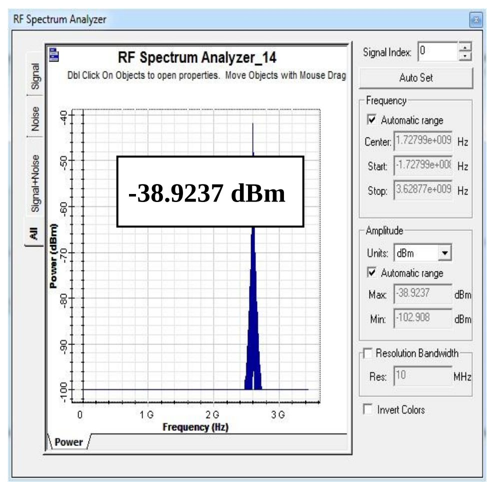

Fig. 13 Simulated total pre-filter in 50 km

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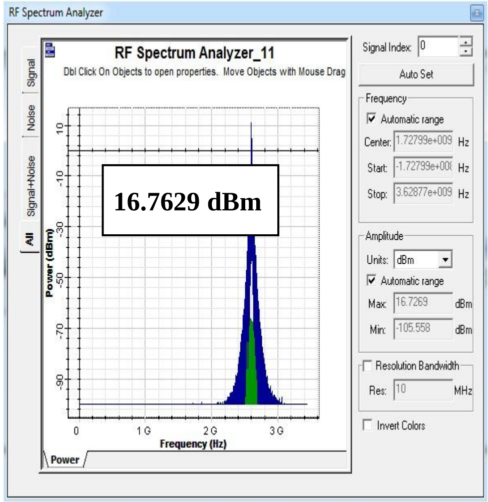

Fig. 14 Simulated total amplifier in 50 km

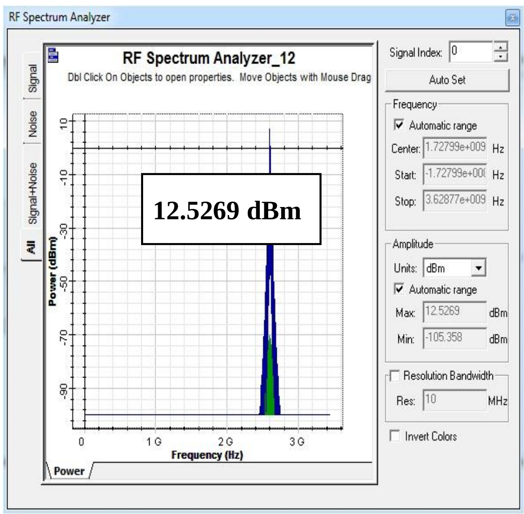

Fig. 15 Simulated total post-filter in 50 km

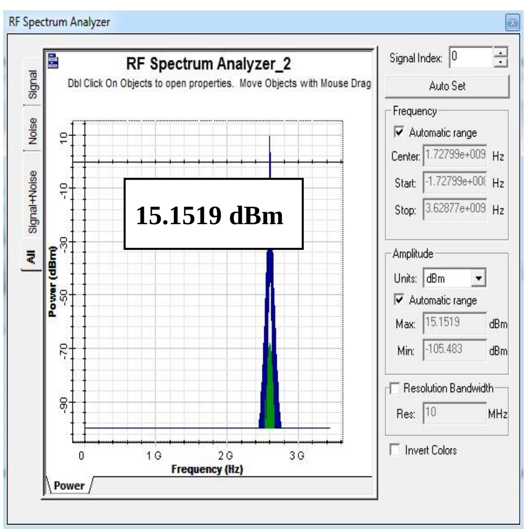

Fig. 16 Simulated antenna in 50 km

For 50 km distance, it seems that the measured output powers of all of the components are higher than the simulated output powers of all the components involved. All of them do follow the sensitivity to be more than -65 dBm. However, compared to 1 km and 10 km distance, the output powers for 50 km do follow the specifications of radiated power, which are lower than 30 dBm, except for measured transmitter antenna, which is still higher than 30 dBm, at the value of 49.0543 dBm.

6.0 CONCLUSION

The downlink radio access point (RAP) for radio over fiber system (RoF) for LTE applications has been designed by making a lot of research on the components used to find a compatible amplifier circuit and filter for the best optical signal detection, antenna to transmit signal, and fiber optic cable to transmit the signal for a long distance.

The downlink radio access point (RAP) for radio over fiber system (RoF) for LTE applications has been simulated by using OptiSystem software. During the simulation, the data are obtained from 2 sources, which are from the factory, and also the components with a fixed value inside the software.

The performance of signal noise ratio (SNR) for downlink transmission has been analyzed by using OptiSystem software. By analyse the performance of the signal, a good service quality of coverage can be provided at a central station with a distributed antenna system constructed using optical fiber cable.

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