Comparative analysis of the dispersion compensating fiber (DCF) scheme in long-haul dense wavelength division multiplexing (DWDM)

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Abstract. Dense wavelength division multiplexing (DWDM) technique in optical communication was used to improve the system performance combined several channels in a transmission line especially for long-haul optical link, but the presence of dispersion limited the system performance. The Dispersion, one of the distortion in optical communication system, influenced the performance of dense wavelength division multiplexing (DWDM) by limiting the bandwidth capacity, so the DWDM system required a tool to compress the effect of dispersion. This works aimed to analyse performance of the DWDM systems using the bit error rate (BER) and Q-factor parameter that implemented the symmetrical DCF to compress the dispersion effect. Observation were made on a model of 16-channel DWDM with bitrate 40 Gbps, over 1050 km optical link with channel spacing 100 GHz. The DWDM system was design using two DCF configurations and Erbium Doped Fiber Amplifier (EDFA) to regenerate the optical signal. The system performance was observed with optical power launch variations of 0, 2, 4, 6, 8 dBm and variations in the DCF scheme (type-A and type-B). Based on results, Type-A performance is slightly better in terms of Q-factor than the B-type scheme. Based on BER value, both type-A and type-B performance have equivalence value. In conclusion, the different scheme for DCF placement to compensate the dispersion effect in DWDM shows the equal performance.

1. Introduction

The optical fibre communication system is one of the transmission technology that uses light as a data transfer with wide bandwidth. Dense Wavelength Division Multiplexing (DWDM) is one of the techniques that can transmit a lot of existing signals using wavelength. DWDM is commonly used in remote transmission, but DWDM system has deficiencies in dispersion system. Dispersion is a problem that occurs due to widening the pulse in the transmission, resulting in a decrease in performance on the system [1].

In a journal titled "Performance Comparison of Dispersion Compensation Schemes Using DCF in DWDM Optical Network" [1] which talks about pre-compensating, post-compensating, Fortescue-compensating which uses 16 channels with 200GHz Channel and 40 Gbps bitrate, using a range of 300km, which results in pre-compensating 18,334, post-compensating 17,904, and symetrical-compensating 19,572. While in the journal "The influence of dispersion cable Compensating Fiber (DCF) on the Link Optical communication system Long Haul with different schemes" [2] discussing
the pre compensation scheme, mix compensation schemes, and parallel schemes compensation, which Uses 10 Gbps bitrate with a distance of 300 km which results in a pre-kompensation scheme of 2.5, mix compensation Scheme 9.5, and parallel compensation Scheme 8.1. In monitoring the performance of a network with DWDM technology There is a parameter that is the benchmark of the network whether or not the network whether or not it needs to be improved, so that the evaluation required in each parameter To view the quality of the parameters [2].

The thesis was compiled with a reference from a thesis journal titled "Performance Comparasion of Dispersion Compensation Schemes Using DCF in DWDM Optical Network" [2] written by Fahmi, a difference with this thesis in the Journal of thesis Used as a reference for making comparisons to the DCF scheme. Based on the background above then the author took the title of the thesis titled "Analysis of the reference of Unjukkerja Compensating Fiber dispers ion scheme (DCF) on Long Haul Dense Wavelength Division Multiplexing (DWDM)". That will compare the show's 2 DCF trial schemes. The first paragraph after a heading is not indented.

2. Literature Review
In Khair research journal [1] in 2018 conducted a study titled "Performance Comparasion of Dispersion Compensation Schemes Using of DCF in DWDM Optical Network" discussing about comparing DCF schemes suitable for use on the network DWDM that uses 16 channels with bit rate 40 Gbps per channel, 200 GHz channels and with an optical cable of 300 km. Then it concludes that the Q-factor values of pre-compensation, post compensation, and Fortescue compensation are not Meets ITU-T standards that have a Q-factor value of more than 7.20 values. However when the Fortescue compensation values are given input power of 0 dBm, 2 dBm, 4 dBm, 6 dBm, 8 dBm, and 10 dBm, it can provide a positive impact. Fortescue compensation schemes are better or optimally compared to other schemes.

In a research journal Achmad Wildan Almaiz [3] conducted a study titled "Influence of Cable Dipersion Compensating Fiber (DCF) on Link optical communication system Long Haul with different schemes" which discusses how to optimize the network Optics with a distance of 1000 km and data rate at 10 Gbps as a comparator. The scheme used 3 is simulated without DCF, then the DCF simulation with 3 schemes, and the most popular SM and DCF installed in parallel. Then the scheme is supported by the amplifier Ebrium Doped Fiber Amplifier (EDFA) of 22 dB. When conducting the first schema test, the scheme without DCF generates a very large Q-factor value and the maximum value is at a distance of 100 km, while the post compensation scheme gets the maximum value at a distance of 400 km, on the pre Compensation is the maximum value at a distance of 600 km, in the mix compensation scheme it generates the maximum value at a distance of 600 km, and on the parallel compensation scheme get the maximum value at a distance of 400 km.

In the research journal Ade Rizki Ginanjar [4] conducted a study titled "Analysis and Simulation of Dispersion Compensation Fiber influence on optical Link based on distance and Bit Rate" which discusses the calculation of pre Compensation and post Compensation on Dispersion Compensating Fiber (DCF) uses a distance of 150 km, 500 km and 1000 km with bit rate of 10 Gbps and 40 Gbps and uses multiplexing DWDM using DCF mix compensation scheme. The results sought on this study were the Q-factor value, and after conducting research at a distance of 1000 km with bit rate of 10 Gbps and 40 Gbps get the value of Q-factor = 0. The Q-Factor value at 10 Gbps bit rate is only maximum up to 500 km, while at 40 Gbps bit rate only up to 80 km distance.

3. Methods
This research conducted by several stages started by making a review of the literature, formulation of problems, stages of determining system parameters to be used on the system, designing using the Optisystem, as well as the stages of making Analysis of the test results of the system and make conclusions of the analysis results of the simulation that has been done.
In Figure 1 shows the block diagram of the system that has been designed to be 2 schemes, namely the Fortescue Compensation Type-A scheme and the Fortescue Compensation Type-B scheme. It will then compare which schemes are better based on the Q-factor value and Air conditioned.

![Block Diagram Compensation Type A (a) and Compensation Type B (b)](image)

System design was applied using 16 channels, using a data speed of 40 Gbps on each of its canals. Using a channel spacing of 100 GHz at a frequency range of 189.6 – 191.1 THz. With a variation of the power of 0, 2, 4, 6 and 8 dBm as show in Figure 3.
Figure 2. Subsystem Transmitter Design

The transmission system consists of Singlemode Fiber (SMF), Dispersion Compensating Fiber (DCF), and amplifier Erbium Doped Fiber Amplifier (EDFA). In the fiber section of SMF has a distance of 700 km, with a dispersion value of 18.5 PS/nm × km, dispersion slope 0.06 PS/nm × km, and the value attenuation 0.187 Db/km. For the compensator fibre of DCF has a dispersion value of 37 PS/Nm × km, the dispersion of slope of 0.12 PS/nm × km, and the damping value is 0.24 dB.

Figure 3. Subsystem Transmission Link Design Type-A
Figure 4. Subsystem Transmission Link Design Type-B

Figure 3 shows the transmission link for compensating type A and Figure 4 shows the transmission link for compensating type B. The difference between type A and type B exist in the SMF and DCF configuration.

Figure 5. Subsystem Receiver

Figure 5 displays the receiver block of the system design consisting of a demultiplexer with the number of 16 canals output using a insertion loss of 4.7 dB. The Optical Receiver is used to detect signals on every channel with A/W responsiveness value and dB gain.

4. Results and Discussion
The comparison of the show results in the Fortescue Compensation type A scheme and the Fortescue Compensation type B scheme obtained the Q-factor value obtained based on the average value of 16
channels used with the comparison scheme with a variation of the power of 0, 2, 4, 6 and 8 dBm were flown only in the channel space 100 GHz with a distance of 1050 km.

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**Figure 6.** Comparison of the Average Q-factor Value of 100 GHz channel spacing

In the figure 6 shows the average chart of Q-factor values in the Fortescue Compensation type A scheme and the Fortescue Compensation type B scheme. Obtained from the variation of power variations of 0, 2, 4, 6 and 8 dBm. From the graph can be obtained that as the power increases given, it will improve the system quality based on the Q-factor parameter. From the image can also be seen that the type A scheme is better than the type B scheme.

In addition to the Q-factor parameters, the system performance comparison is also obtained by the average values of DWDM 16 channel based on the parameter of Bit Error Rate (BER) between Fortescue Compensation type A and Fortescue compensation type B scheme.

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**Figure 7.** Graph of Comparison of the Average Value of a 100 GHz Channel Space BER.

In Figure 7 shows the average graph of the BER value in the Fortescue type scheme and the offset Fortescue scheme type B acquired from the power variation of 0, 2, 4, 6, and 8 dBm. From the chart
can be obtained that as the power increase used will suppress the system. From these charts did not undergo significant changes, but if viewed carefully the type B scheme has a smaller BER value than type A.

5. Conclusion
Based on the discussion on the comparison of the 16-channel DWDM system performance using the Compensation type A scheme and the Compensation type B scheme, which are variated in the 0, 2, 4, 6, and 8 dBm in the channel spacing of 100 GHz. From the schema comparison the Fortescue Compensation type A scheme was slightly better than the Compensation type B scheme.

6. References

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