APPLIACTION OF QAM SGNALS TO OIL & GAS OADM SUBMARINE CABLE SYSTEM

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Abstract: In the monitoring systems of the OIL & GAS sector, it is necessary to select the fiber configuration and modulation format. The digital coherent format is effective in the coexistence of the monitoring signal and a normal communication service.

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1. Monitoring System

During optical communication system monitoring of the OIL & GAS sector, there are systems transmitting only a monitoring signal and a coexisting system monitoring signal, and normal communication service. The latter is able to achieve a reduction in cost. It is necessary to secure both the signal quality of monitoring signals and the signal for normal communication services.

The assumed configuration is indicated in Fig 1. It consists of terminals, monitoring stations, trunk part, OADMs, and branches. OADM consists of optical couplers and band rejection filter. The repeater is of the same type in the trunk and branch. An assumed parameter is described below.

One wavelength is used to monitor each monitoring point respectively.
From the station, the monitoring signal is transmitted at that wavelength. For keeping the input power constant, the signal is combined with DL (Dummy Light) and sent to the branch fiber.

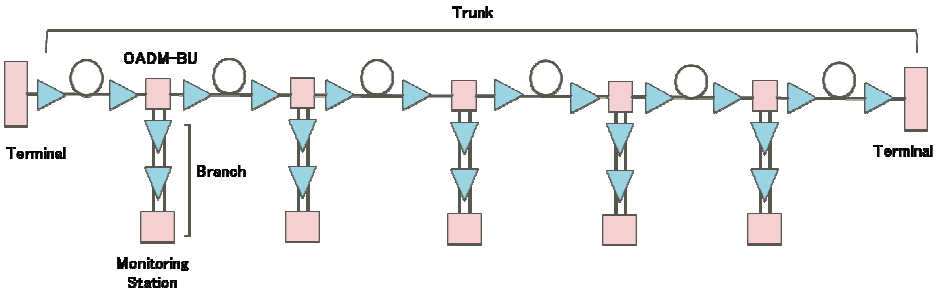

Fig. 1 Network configuration of monitoring system

The DL is cut by the band pass filter, and not transmitted to the trunk fiber.

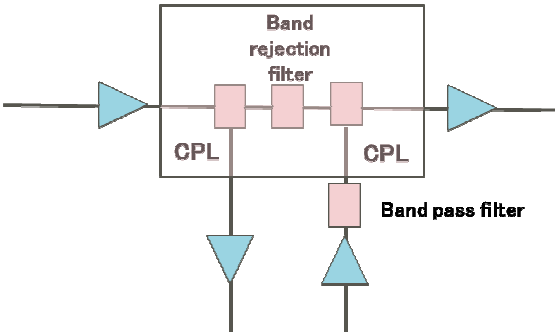

Fig. 2 OADM configuration

Because of the loss compensation of OADM, there is a need to place a repeater. It is necessary to increase the repeater number to the same number as the number of OADM. Since OSNR degradation may be caused, it is necessary to select the system configuration of low required OSNR.

Further cross-talk from the band rejection filter and the band pass filter degrades the signal quality.
Adding one transponder increases by one of OADM, the maximum transmission distance becomes short by one span length.

2. Transmission line configuration and modulation format

Line configuration has two types. One configuration includes dispersion compensation fibers in the line and suppresses the accumulated dispersion that becomes large in a transmission line. Another configuration does not include the dispersion compensation fiber.

The former (Fig. 3) is suitable for direct detection (DD) and the latter (Fig. 4) is suitable for digital coherent detection that is capable of compensating ps/nm inchromatic dispersion.

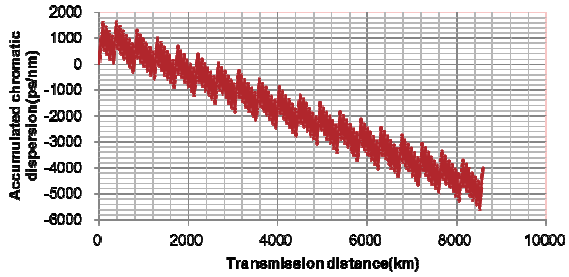

Fig. 3 Dispersion map for DMF

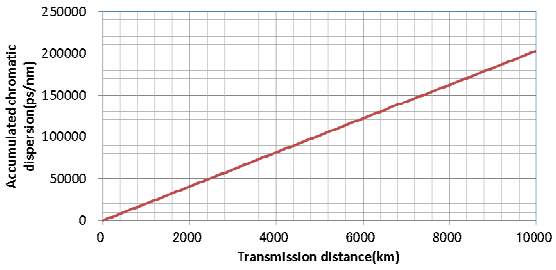

Fig. 4 Dispersion map for all SMF systems

But the maximum transmission distance is more inferior to the former than the latter. This is because that SPM is enhanced by recover waveform distortion, and XPM is also enhanced for recovering the relative delay between own signal and the adjacent channels.

Required OSNR of 16 QAM and 8 QAM compared to QPSK, respectively, large 5dB and 8dB. Further, on the other hand, SE is QPSK, 8QAM, 1.5 times 16QAM, twice.
Therefore, it is possible to use higher order QA signal from trunk only relatively close to the branch landing station of trunk

The digital coherent system is subject to restrictions of tracking speed to a high-speed polarization fluctuation. A polarization fluctuation higher-speed than a usual submarine landing section is expected at a fiber draw part in the monitoring area, so it is necessary to set a parameter in order to permit to a polarization fluctuation.

An example of the reach estimated from the required OSNR is indicated in Table-1.

Table-1 Estimated reach(km)

	QPSK	8QAM	16QAM
all +D	1200	3000	1600
DMF	8000	2000	1000
NZ-DSF	4000	1000	500

All +D is all SMF with large core
DMF is Dispersion managed fiber
NZ-DSF is Non Zero –Dispersion Shifted Fiber

The modulation system and fiber composition according to the scale of the network are chosen.

Further, a GB (Guard Band) of 200 GHz is necessary between the wavelength of 10G IM signal and the coherent signal by

NZ-DSF (Non Zero –Dispersion Shifted Fiber) system. When 3000 km is exceeded at equivalent zero dispersion region, the signal begins to degrade for GM (Gordon–Mollenauer) phase noise, so it is necessary to appropriate the degradation amount for budget.
When 5000 km is exceeded, but the reach in QPSK does not extend, it is not necessary to consider a large degradation.

3. Bandwidth design

Band limiting of the maximum capacity of the trunk is determined by the repeater gain profile, which is usually in EDFA about 50 GHz by 80 ch. Since the monitoring signal assigns only one wave to each station, if there are *m* stations, it gives *m* waves.

To monitor a plurality of stations at the same wavelength, the influence of the fiber cut branch portion undesirably affects the monitoring of the plurality of stations.

The wavelength of normal service is reduced by that amount.

Also, according to the rejection band profile of the rejection filter, there is a possibility that the adjacent wavelength slot cannot be used. In that case, it will not be possible to use the 3m x 50GHz.

The adoption of flex grid and Nyquist filter, there is a possibility to reduce this excessive prohibited region.

4. Non-linear compensation

Nonlinear compensation circuits are used to compensate the degradation of specific signals that occurs in fiber nonlinearity [3], to improve the signal quality obtained. Although it is possible to obtain a relative high Q value by this feature, it is impossible to compensate for the effects from the adjacent signal.

The improvement amount is about 1dB. In order to increase the OSNR, it is necessary to increase the fiber input power by 1 dB. An improvement of 0.5 is expected even if we do not raise the fiber input power.

5. Upgrade

When OSNR can be secured by a monitoring system of existence 10G IM-DD, it is possible to upgrade using coherent signal.

When the filter to pass 1 wave of 10G is adopted, it's necessary to appropriate a penalty of shaving spectrum. It is necessary to apply a Nyquist filter and achieve reduction in penalty.

6. Conclusion

Using the digital coherent modulation scheme as the monitoring signal, it will be able to adopt all SMF (+ D) type configuration containing no line DCF that can extend the reach to monitoring signal transmission and normal communication service. It makes easier to adopt the 8QAM / 16QAM that have high spectrum efficiency and relatively short reach.
In addition, non-linear compensation can further extend the reach and build a flexible monitoring system.

7. EFERENCES

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