10A1-4

Impact of Polarization Mode Dispersion on Analog Video Transmission over PON system

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Abstract: Signal degradation of analog video optical transmission over fiber to the home system, caused by polarization mode dispersion, has been examined. It was revealed that dynamic changes of PMD degrade signal quality.

1. Introduction

Signal distortion in analog lightwave systems caused by polarization mode dispersion (PMD) has been investigated [1]. This degradation could be significantly reduced by use of low chirp lasers in optical transmitter, however, it is still considerable even with low PMD value of single digit [2,3]. Especially, recent wide spread of Passive Optical Network (PON) system over the world rose issues related to RF video overlay seriously because its optical transmission distance (~20km) is relatively longer than those of common distance of analog optical transmission (a few kilometers) [4].

PMD is an effect to separate fundamental spatial mode into two orthogonal polarization modes, caused by birefringence, which is remained permanently in fiber through manufacturing process or stressed by eternal condition changes such as temperature changes. As environmental conditions vary constantly, PMD effects show stochastic behavior. It is well know that PMD values distribute along Maxwellian distribution and it has wavelength and time dependence. As a result, temporal changes of PMD might degrade signal quality of analog video as well as static PMD effects.

PON systems for Fiber to the home (FTTH) usually use OLT (Optical line terminal) and ONTs (Optical network terminal) to communicate a service provider with subscribers. To reduce service cost, information signal is equally divided by remote node between OLT and ONTs. The fiber feeding scheme to each subscribers depends on each individual situation but mostly the feeding fibers come under the influence of environmental changes such as temperature, rain, and winds. (Figure1)

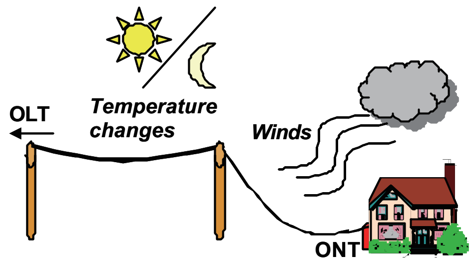

Figure 1: Schematics of FTTH and environmental effects

Usually, video signal quality, degraded by impairments, is evaluated with CNR (Carrier to signal ratio), CSO (Composite second order beat), and/or CTB (Composite triple beat) [2]. And it states that the video signal less than certain amount of those numbers are bad quality. However, it is unclear how bad it is. For example, degradation over entire screen could not be recognized when the degradation amount is small. On the other hand, it is obviously felt uncomfortable if the screen has white flickering horizontal lines even though it is very minor. Thus, in this study, we evaluated video signal quality against temporal varying PMD by using subjective observation.

2. Experiment

To verify PMD effects against other fiber impairments, we used two experimental setups. Figure 2 (1) shows simple setup without PON configuration as well as 1490nm data signals. The second configuration (2) has a HGPON [5] remote node and data signals. Analog video signal operates at 1555nm and is amplified by an EDFA to 20dBm. The RF video input to the transmitter is a video modulated carrier of channel 3 @ 61.25MHz.

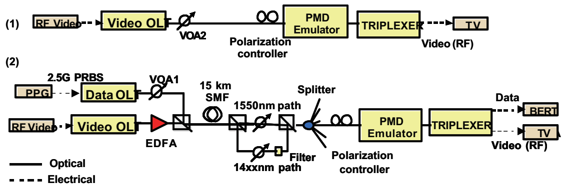

Figure 2: Experimental setups

Signal input powers in case of configuration (1) and (2) to Rx were –6.5dBm, and –2.7dBm, respectively.

Only first order PMD (differential group delay: DGD) was introduced with General Photonics PMDE-301. Input state of polarization was fixed 45 degree (worst case) and changes instantaneous DGD value along Maxwellian distribution of given PMD. The time of each PMD states were varied from 10ms to 500ms.

3. Results and Discussion

Photo 1 shows the degradation (flickering white horizontal lines) caused by temporal changes of PMD. These lines came up when a few pico-second PMD was introduced. (The bad quality of the photo itself is not related PMD.) In case of very high speed changing each DGD states (10ms), white lines became annoying even with low PMD value of 2ps.

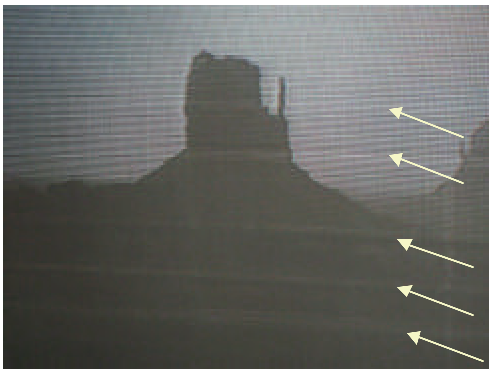

Photo 1: Video screen with white horizontal lines caused by PMD

Table 1 summarized observations. Frequency of white lines strongly depends on PMD value, and time of each DGD states. As aerial fibers, which are usually used for FTTH, tend to have shorter time of DGD states, those systems should consider total PMD carefully. Results after fiber transmission should be same, as those without transmission, however it looks slightly better because of other degradation made them not relievable.

Test Setup	(1)	(1)	(1)	(1)	(2)
Time period	10ms	50ms	100ms	500ms	50ms
0ps PMD					
2ps PMD	v	v			v
4ps PMD	v	v	v		v
8ps PMD	vvv	vv	v	v	v
12ps PMD	vvvv	vvv	v	v	vv
16ps PMD	vvvv	vvv	vv	v	vv
20ps PMD	vvvvv	vvvv	vv	v	vv

Table 1: Frequency of flickering white horizontal lines on the video screen. (v represents number of the lines in a screen)

Note: Although 2ps PMD is generated easily on a PON configuration (e.g. 20km fiber, EDFA, WDM filter, Splitter), rotating signal polarization by external changes can help to reduce degradation by PMD significantly against this experiment's worst-case setup.

4. Conclusion

We investigated PMD effects on analog video optical transmission over PON system. Only a few PMD value could generate flickering white horizontal lines on video screens if the DGD value frequently changes with the worst input polarization state.

References

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