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Improvement Scheme for Directly Modulated Fiber Optical CATV System Performances

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1. Introduction

In an optical CATV system, the signal was directly or externally modulated with lightwave before communicates. Directly modulating signal with LD is an economic method, but the transmission distance and performance are significantly limited by laser chirping issues. In another hand, the externally modulation schemes have been proofed to provide better outcomes by eliminating the laser chirping issue. Nevertheless, an expensive externally modulated transmitter is required causing an increased capital expenditures. In order to provide an economic structure with advanced transmission performance as in external modulation system, direct modulation method is often combined with other techniques or components to compose higher performance and lower cost CATV system. The split-band techniques for example have been proofed as a powerful assistant for direct modulation CATV systems. In this structure, the full channel loading is shared by additional LDs causing a wider optical linewidth to eliminate the SBS degradation. In addition, by increasing the wavelength numbers, major parts of CSO distortions from each transmission band are automatically removed from each channel. These outstanding techniques and impressive outcomes are consequently analyzed and discussed as parts of this chapter.

In parallel with the effective of the SBS degradation, the CNR is in direct proportion to the optical power, as well as the second-order harmonic distortion-to-carrier ratio (HD_2/C) and the third-order inter-modulation distortion-to-carrier ratio (IMD_3/C) values are in inverse proportion to the laser resonance frequency. Improving the utilized LD characteristic is therefore another useful methodology to upgrade the optical CATV system. External light-injection and optoelectronic feedback techniques in particularly have been experimentally proofed as efficient methods to enhance laser output power and laser resonance frequency (Lee et al., 2007; Lu et al., 2008). As a result, the CNR value will be proportionally increased with the enhanced LD intensity, as well as the HD_2/C and IMD_3/C will be proportionally reduced with the improved laser resonance frequency. The reduced HD_2/C and IMD_3/C values are subsequently leading to an improvement in CSO/CTB values.

Following with the modifications of modulation schemes and lightwave characteristics, compensating fiber dispersions is another research direction to promote fiber optical CATV systems. Numbers of compensation methodologies such as eliminating parts of optical dispersion by optical filter and cascading systems with negative dispersion fibers are

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demonstrated as useful techniques to upgrade system performance. Since there is no modulating information in the optical carrier, putting an optical filter to eliminate the redundant spectra not only can increase spectra efficiency by reducing the spectral linewidth but also can ameliorate the CSO/CTB performance by reducing frequency dispersion. Similarly, cascading a section of negative dispersion fiber with CATV systems is also an efficient method to eliminate the fiber chromatic dispersion. By combining a negative dispersion fiber with single mode fiber (SMF), the total fiber dispersion is able to be removed to improve the system performance. Consequently, the relative fiber dispersion compensation techniques as well as the possible extensions and the future directions of the CATV systems are also discussed in this chapter.

2. Modulation promotion methods: split-band techniques

Long-distance transmission of fiber AM-VSB 80-channel CATV systems has been widely spread throughout the cable industry. Nevertheless, the maximum transmission distance of such systems is still limited by RF parameters and it is difficult to obtain good CNR, CSO, and CTB performances due to full channel loading (Lu & Lee, 1998). In order to provide an economic structure with advanced transmission performance as in external modulation system, direct modulation method is often combined with other techniques or components to compose higher performance and lower cost CATV system. The split-band techniques for example have been proofed as a powerful assistant for direct modulation CATV systems. In this structure, the full channel loading is shared by additional LDs causing a wider optical linewidth to eliminate the SBS degradation (Lee et al., 2007). In addition, by increasing the wavelength numbers, major parts of CSO distortions from each communication band are automatically removed from each communication channel.

Fig. 1 shows two AM-VSB 80-channel fiber optical CATV systems with two cascaded EDFA's (Lu & Lee, 1998). Fig. 1 (a) (referred to as system I) shows the conventional 80-channel fully loaded externally modulated system. Fig. 1 (b) (referred to as system II) shows a half-split-band directly modulated WDM system with 40 channels per transmitter.

In system I, channel 5~78 (77.25–547.25 MHz) are fed into an external modulator as the modulation signal through an RF predistortion circuit. The interaction of the 1550 nm DFB laser light and the RF-generated electric fields leads to a phase modulation via the electrooptical effect. The phase modulation was then converted to intensity modulation within the external modulator. During this converting process, the linewidth is broadening by the phase modulation causing a reduced SBS effect. While in system II, channel 5~40 (77.25–319.25 MHz; low bands) are fed into the first directly modulated transmitter, and channel 41~78 (325.25–547.25 MHz; high bands) are fed into the second one. Channel (55.25–67.25 MHz) are removed from system II to obtain best CSO value.

Fig. 2 (a)–(c) shows the measured CNR, CSO and CTB values under NTSC channel number for both system I and II respectively. Comparing with the system I, the CNR and CTB values in the system II are relatively degraded about 2 and 0.2 dB. Nevertheless, the CSO performance in the system II is much better than in system I especially at the high bands region.

This improvement, resulted from the use of half-split-band and WDM techniques, is caused by the reduction of fiber nonlinear and dispersion effects. For example, when the carrier frequency for CH_7 and CH_{13} is 175.25 and 211.25 MHz respectively, there will be a CSO distortion at:

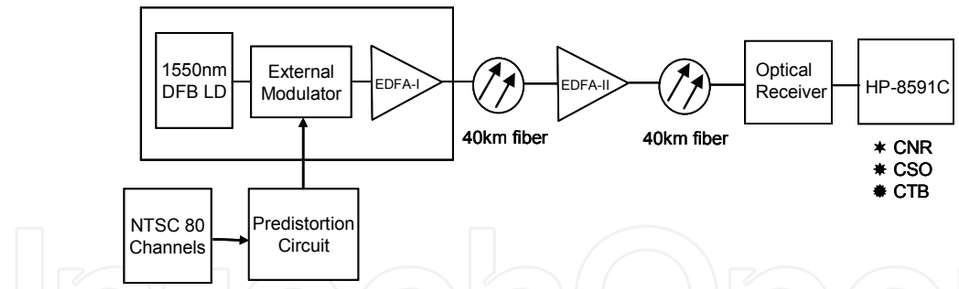

Fig.1(a)

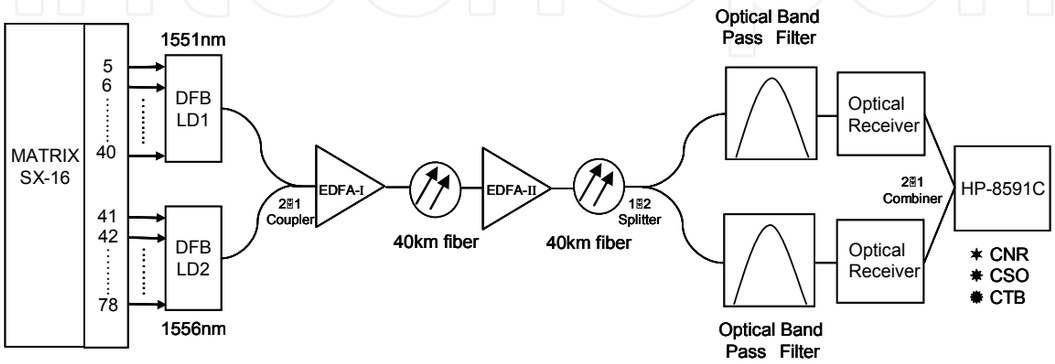

Fig.1(b)

Fig. 1. (a) Fully loading externally modulated transmitter system and (b) directly modulated transmitters using half-split-band techniques (Lu & Lee, 1998).

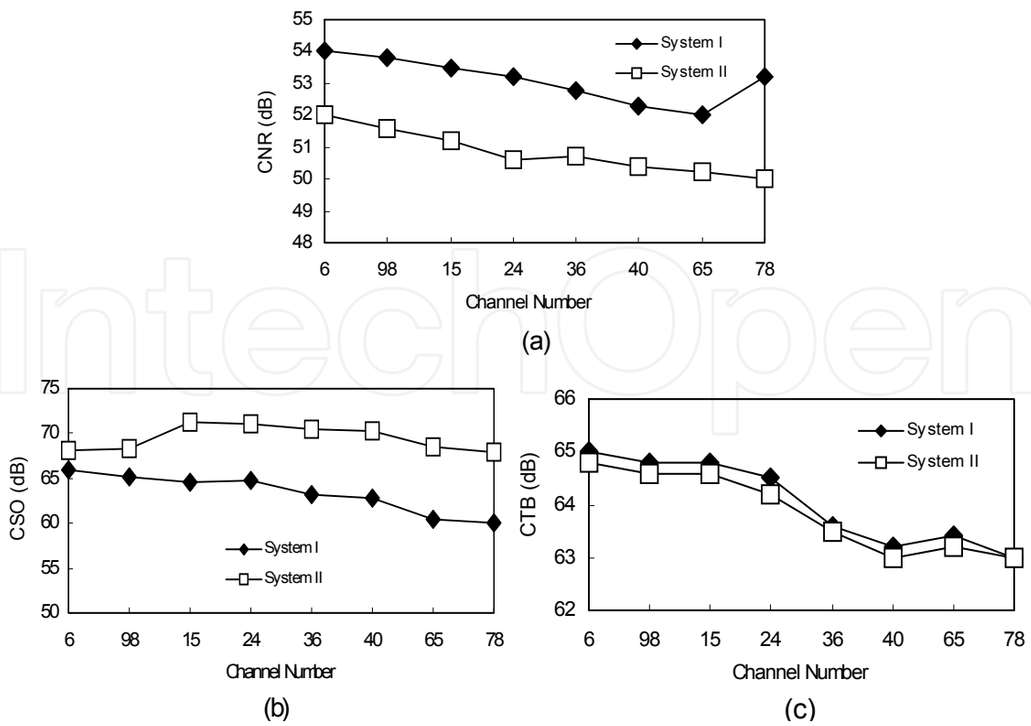

Fig. 2. (a) Measured CNR, (b) CSO and (c) CTB values for systems I and II. (Lu & Lee, 1998).

$$175.25\text{MHz } (CH_7) + 211.25\text{MHz } (CH_{13}) = 386.25 \text{ MHz}. \quad (1)$$

Similarly, the CSO distortion caused by CH_{78} and CH_{50} is located at:

$$547.25\text{MHz } (CH_{78}) - 379.25 \text{ MHz } (CH_{50}) = 168\text{MHz}. \quad (2)$$

The above results present that the CSO distortions induced by low bands (CH_5 ~ CH_{40}) are located at high bands, and CSO distortions induced by high bands (CH_{41} ~ CH_{78}) are located at low bands. The half-split-band technique is therefore can remove major part of CSO distortions in system II to improve the transmission performance.

3. Lightwave enhancement schemes: light-injection techniques

In contrast to transform the modulation techniques, boosting up LD performance is another valuable technique to be recoded in here. External light-injection techniques and optoelectronic feedback techniques in particularly have been experimentally proofed as efficient methods to improve optical fiber CATV systems (Lee et al., 2007). By externally injecting a master light source into a slave laser, the output power and laser resonance frequency of the injection-locked slave laser can be greatly enhanced (Kazubowska et al., 2002; Lee et al., 2006). The CNR value is consequently proportionally increased with the enhanced LD intensity, as well as the HD_2/C and the IMD_3/C are proportion reduced with the laser resonance frequency. The reduced HD_2/C and IMD_3/C values in the light-injection optical CATV systems will lead to an improvement in CSO/CTB performance. As a result, the light-injection techniques can notably improve the lightwave features to transmit CATV programs.

3.1 Local light-injection techniques

Fig. 3 shows a directly modulated transport system employing external light injection technique to improve the overall system performance (Lu et al., 2003). The central wavelengths of the two DFB laser diodes are 1550.5(λ_1) and 1555.7(λ_2) nm respectively.

In the system, the frequency response of the DFB laser diode with and without external light injection is very different. In the free running case, the laser resonance frequency is ~5 GHz; with 3 dBm light injection, the laser resonance frequency is increased to ~15 GHz; and with 4.8 dBm light injection, the laser resonance frequency is further increased up to ~18.5 GHz. The 370% improvement in the laser resonance frequency has significantly demonstrated the advancement of the external light injection techniques to assist the fiber optical CATV systems.

Fig. 4 (a) shows the measured CNR values under NTSC channel number with and without external light injection respectively. It can be seen that the CNR values are boosted up with the increasing of the injected power level. For long-haul lightwave transmission systems, the CNR values are dominated mainly from signal-spontaneous beat noise (Way, 1998):

$$CNR_{sig-sp}^{-1} = \frac{8 n_{sp} h\nu}{m^2 c_1^2 P_{in}} (1 - \frac{1}{G}) \quad (3)$$

where $CNR_{sig\text{-}sp}$ is associated with the EDFA, n_{sp} is the population inversion factor, $h\nu$ is the photon energy, m is the optical modulation index, c_1 is the input coupling loss to the EDFA,

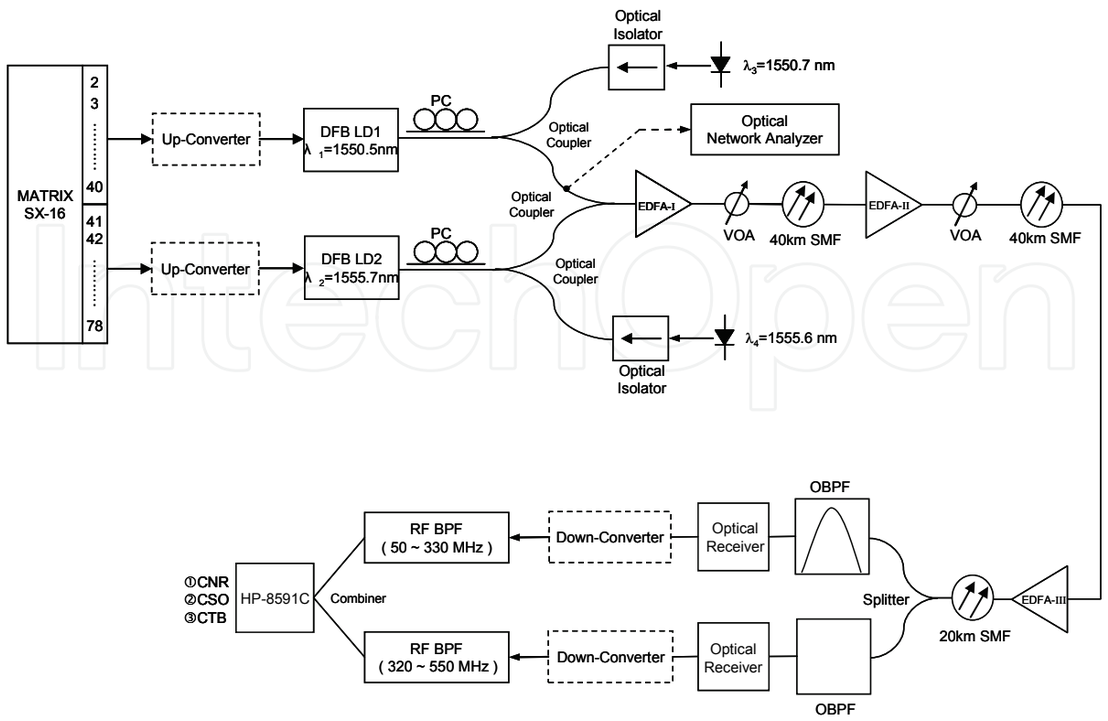

Fig. 3. Directly modulated transport system employing external light-injection technique (Lu et al., 2003)

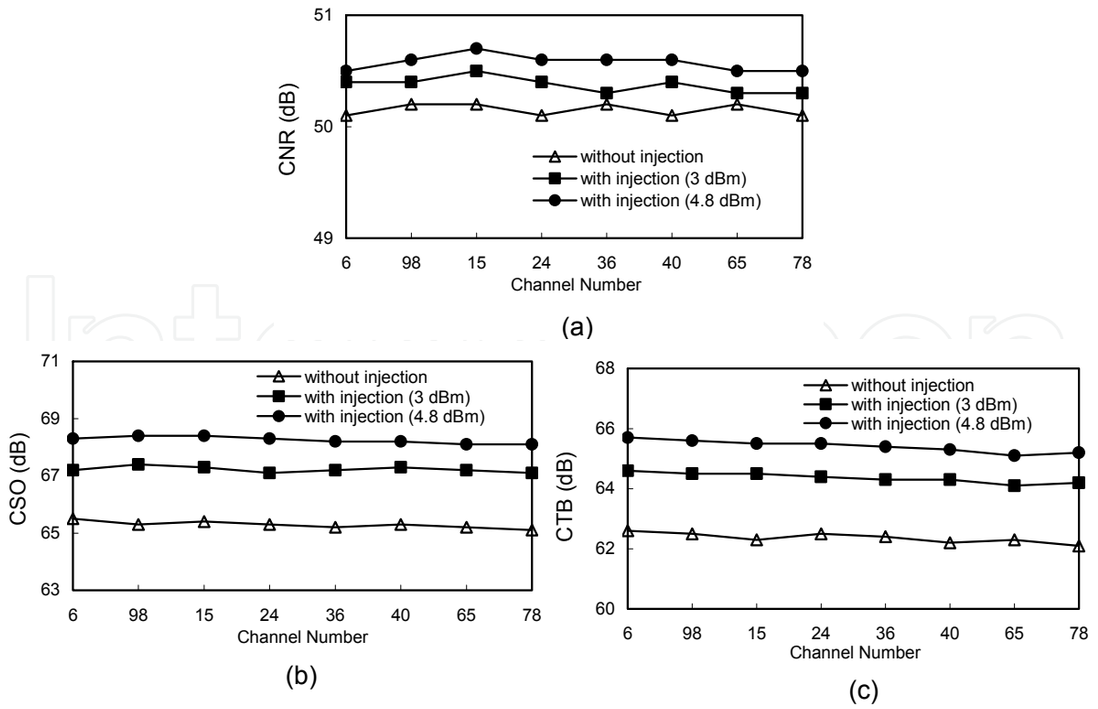

Fig. 4. (a) Measured CNR values with and without light injection. (b) The theoretical derived and experimental measured CSO and (c) CTB values.(Lu et al., 2003)

P_{in} is the EDFA optical input power, and G is the saturated gain of the EDFA. From the above equation, it is clear that the $CNR_{sig\text{-}sp}$ value depends critically on the optical input power P_{in}. When the injection power is increased, the power launched into the EDFA-I is enlarged. This is attributed by a fact that the external light injection will reduce the laser diode threshold current and then increase the optical output power of the laser diode (Kazubowska et al., 2002). As a result, the CNR performance is upgraded by the techniques.
In parallel with the CNR values, the CSO and CTB values can also be improved by using half-split-band and external light injection techniques. According to the analysis in (Lu & Lee, 1998), the CSO and CTB distortions can be expressed as:

$$\mathrm{CSO} = \mathrm{HD_2} + 10\cdot\log \mathrm{N_{CSO}} + 6\ (\mathrm{dB}) \tag{4}$$

$$\mathrm{CTB} = \mathrm{IMD_3} + 10\cdot\log \mathrm{N_{CTB}} + 6\ (\mathrm{dB}) \tag{5}$$

where HD_2 is the second order harmonic distortion, IMD_3 is the third order intermodulation distortion, N_{CSO} and N_{CTB} are the product counts of CSO and CTB respectively. Smaller N_{CSO} and N_{CTB} can be obtained from the smaller channel number. Therefore, the CSO and CTB values presenting in Fig. 4 (b) and (c) can satisfy the fiber optical CATV systems' requirements (>65/60 dB) (Lu & Lee, 1998).
In addition, it also can be observed that CSO and CTB improvements of ~2 and ~3 dB have been achieved with 3 and 4.8 dBm light injection respectively. This means that the external light injection technique not only can increase the laser resonance frequency, but also can reduce the HD_2/C and IMD_3/C. The HD_2/C and IMD_3/C can be expressed as (Helms, 1991):

$$IMD_3 / C = \left\{ \left[\left(\frac{f_1}{f_0} \right)^4 - \frac{{f_1}^2}{2{f_0}^2} \right]^2 + \left(\frac{f_1}{f_0} \right)^2 \left[\frac{1}{4\pi f_0 \tau_n} - \left(\frac{f_1}{f_0} \right)^2 \left(2\pi f_0 \tau_p + \frac{3}{4\pi f_0 \tau_n} + \frac{3\varepsilon S_0}{2\pi f_0 \tau_p} \right) \right]^2 \right\} \tag{6}$$

$$HD_2/C = m^2 \cdot \left| FR\left(2 f_1\right) \right|^2 \cdot \left(\frac{f_1}{f_0} \right)^4 \tag{7}$$

where $FR(f)$ is the small-signal frequency response, f_1 is the modulation frequency, f_0 is the laser resonance frequency, S_0 is the photon density, τ_n is the recombination lifetime of carriers, τ_p is the photon lifetime, and ε is the gain compression parameter with respect to photon density. It is clear from Eq. 6 and 7 that both HD_2/C and IMD_3/C can become very small when $f_1 << f_0$. The use of external light injection technique lets the laser resonance frequency increased, and results in system with lower HD_2/C and IMD_3/C. Furthermore, it can be obviously seen from Eq. 4 and 5 that to reduce HD_2/IMD_3 will lead to CSO/CTB performance improvement. To show a more direct association among Eq. 6, 7 and the experimental results, the electrical spectra of the received signals with and without external injection are given in Fig. 5 (a) and (b). We can see that the flatness of the system with 4.8 dBm external injection is superior to that without external injection resulting in better CSO and CTB performances.

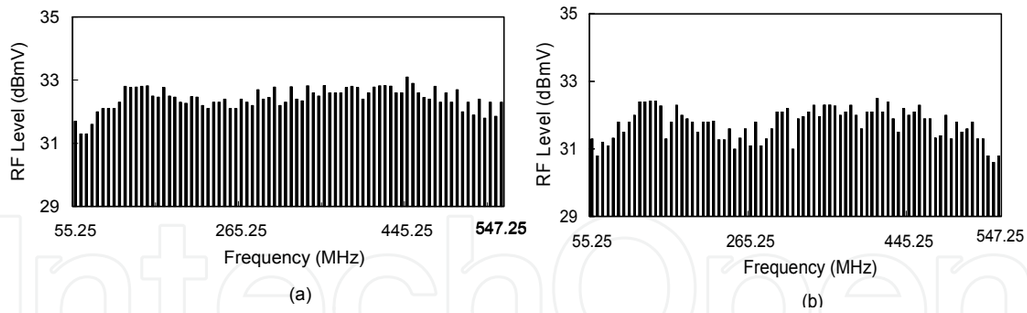

Fig. 5. (a) The electrical spectrum of the received signals with 4.8 dBm external injection and (b) without external injection into the laser (Lu et al., 2003).

3.2 Remote light-injection techniques

In this section, remote light injection technique is discussed. As presented in Fig. 6 (Lee et al., 2007), a total of 77 random phase continuous wave carriers from a multiple signal generator were used to simulate analog CATV channels ($CH_{2\text{-}78}$; 6 MHz/CH), and fed into two DFB LDs. The optical power was coupled into a 50-km SMF through an optical coupler. As to the remote light injection part, 1532.76 nm (λ'_1) and 1535.94 nm (λ'_2) lightwaves with 8 dBm power level are accurately chosen to inject through 3-port optical circulators (OCs). At the receiver end, the power levels of two DFB LDs in the free-running case are decreased obviously due to fiber transmission loss. However, these two power levels are able to be significantly increased by 8 dBm remote light injection and the optical spectra are slightly shifted toward longer wavelengths. This is because that the optimal injection locking condition is found when the detuning between λ_1 (λ_2) and the λ'_1 (λ'_2) is 0.12 nm, and the chaotic phenomenon is found when the detuning between λ_1 (λ_2) and the λ'_1 (λ'_2) is larger than 0.26 nm.

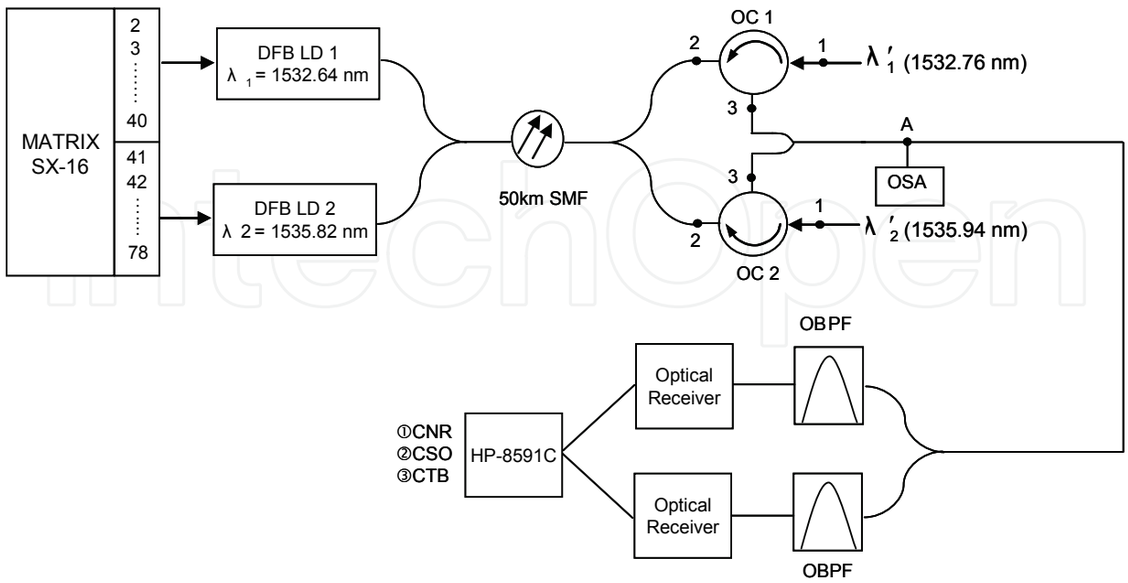

Fig. 6. Remote light-injection direct modulation fiber optical CATV transport systems (Lee et al., 2007).

The measured CNR, CSO and CTB values in the free running case and with 8 dBm remote light injection are presented in Fig. 7 (a), (b) and (c) respectively. It is obvious that the CNR value (≥ 50 dB) is increased largely as 8 dBm optical power is remotely injected. The CNR value depends critically on the received optical power level:

$$CNR = \left(CNR_{RIN}^{-1} + \left(CNR_{th}^{-1} + CNR_{shot}^{-1}\right)\right)^{-1} \tag{8}$$

where CNR_{RIN} results from the LD RIN; CNR_{th} (due to thermal noise) and CNR_{shot} (due to shot noise) are associated with the optical receiver. The summation of CNR_{th} and CNR_{shot} with 8 dBm remote light injection is higher than that in the free running case. This is due to a factor that the optical power is promoted by remote light injection causing a better CNR performance in the receiver end.

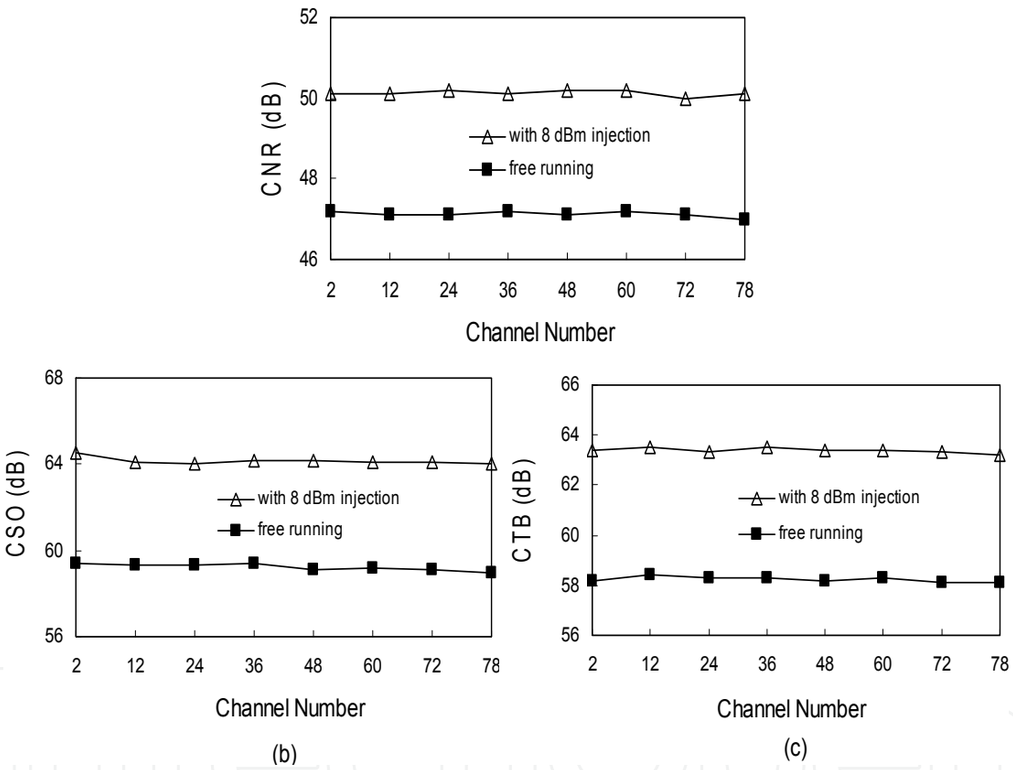

Fig. 7. Measured (a) CNR (b) CSO and (c) CTB values under NTSC channel number (Lee et al., 2007)

As to the CNR performance, the CSO/CTB values (≥65/63 dB) of system with 8 dBm remote light injection are improved considerably. It can be observed from the results that large CSO and CTB improvements of about 6 and 5 dB have been achieved. The improvements are resulted from the use of the half-split-band and remote light injection techniques. CSO and CTB distortions are given by (Way, 1998):

$$CSO = 10\log\left[\frac{mD\lambda_c^{\,2}Lf}{4c}\sqrt{16\left(\Delta\tau\right)^2 + \frac{4\lambda_c^{\,4}L^2\pi^2 f^6}{c^2}}\right] + 10\log N_{CSO} + 6 \tag{9}$$

$$CTB = 10\log\left[\frac{9m^2D^2\lambda_c{}^4L^2f^2}{4c}\left(4\left(\Delta\tau\right)^2+4\pi^2f\right)\right]+10\log N_{CTB}+6 \tag{10}$$

where m is the optical modulation index, D is the dispersion coefficient, λ_c is the optical carrier wavelength, L is the fiber length, f is the RF frequency, $\Delta\tau\left(=|D|\cdot L\cdot\Delta\lambda\right)$ is the fiber chromatic dispersion ($\Delta\lambda$ is the spectral width), and N_{CSO}/N_{CTB} are the product counts of CSO/CTB. By using half-split-band technique, smaller N_{CSO}/N_{CTB} can be obtained from smaller channel number; thereby, part of the CSO/CTB distortion will be removed dramatically in each split-band region. Moreover, the use of remote light injection technique decreases the frequency chirp of LD, letting system with lower fiber chromatic dispersion, and leading to an improvement of CSO/CTB performances.

3.3 Lower-frequency side-mode injection-locked techniques

In the early stage of developing light-injection techniques, researchers are firstly focused their eyes on main mode injection-locked. Nevertheless, this phenomenon was changed by the publications of low-frequency side mode injection-locked techniques (Lee et al., 2006; Seo et al., 2002), because the new method illustrates a much better improvement than main mode injection technique. Table 1 presents the SMSR values under lower-frequency side mode injection-locked of DFB LD at different wavelength detuning. It can be seen that the SMSR values of 40~48 dB are achieved when the locking range is -0.07 ~ +0.32 nm. As optimal injection locking happens, with a detuning of +0.12 nm, the maximum SMSR value of 48 dB is obtained. The injection-locked range for slave laser under light injection can be expressed as (Mondal et al., 2007):

$$-k\sqrt{\left(\frac{I_{in}}{I_m}\right)\left(1+\alpha\right)} \le \Delta\omega \le k\sqrt{\frac{I_{in}}{I_m}} \tag{11}$$

where k and α denote coupling coefficient between injected field and laser field; I_{in} and I_m are injected field and laser mode field intensity, and $\Delta\omega$ is the locking range. Within the locking range, the frequency of slave laser is locked nearly to that of the master laser. Furthermore, with light injection, because of the coherent summation of externally injecting and internally generated slave fields, the phase adds an additional dynamic variable. Consequently, a new resonant coupling between the field amplitude and phase appears and can dominate the laser resonance frequency.

Wavelength Detuning (nm) / SMSR (dB)							
-0.07 /40	-0.04/ 41.5	-0.00/ 43.1	0.03/ 44	0.07/ 45.6	0.07/ 45.6		
0.1/ 46.8	0.12/ 48	0.15/ 46.4	0.18/ 45	0.23/ 43.4	0.25/ 42.5	0.29/ 41.4	0.32/ 40

Table 1. The SMSR values under lower-frequency side mode injection-locked of DFB LD_1 at different wavelength detuning (Lu et al., 2008).

Fig. 8 (a), (b) and (c) show the measured CNR, CSO and CTB values under NTSC channel number for free-running, with 4.8 dBm main mode injection, and with 4.8 dBm lower-frequency side mode injection, respectively. The CNR value depends critically on the optical input power, so that the increased values between the scenarios of 4.8 dBm main and side modes injection are similar. Nevertheless, the performances of the measured CSO and CTB values are very different. According to the Eq. 6 and 7, the use of lower-frequency side mode injection locking technique can further increase the resonance frequency of the slave laser resulting in smaller values of HD_2/C and IMD_3/C. Consequently, better CSO and CTB performances are obtained in 4.8 dBm lower-frequency side mode injection scenario.

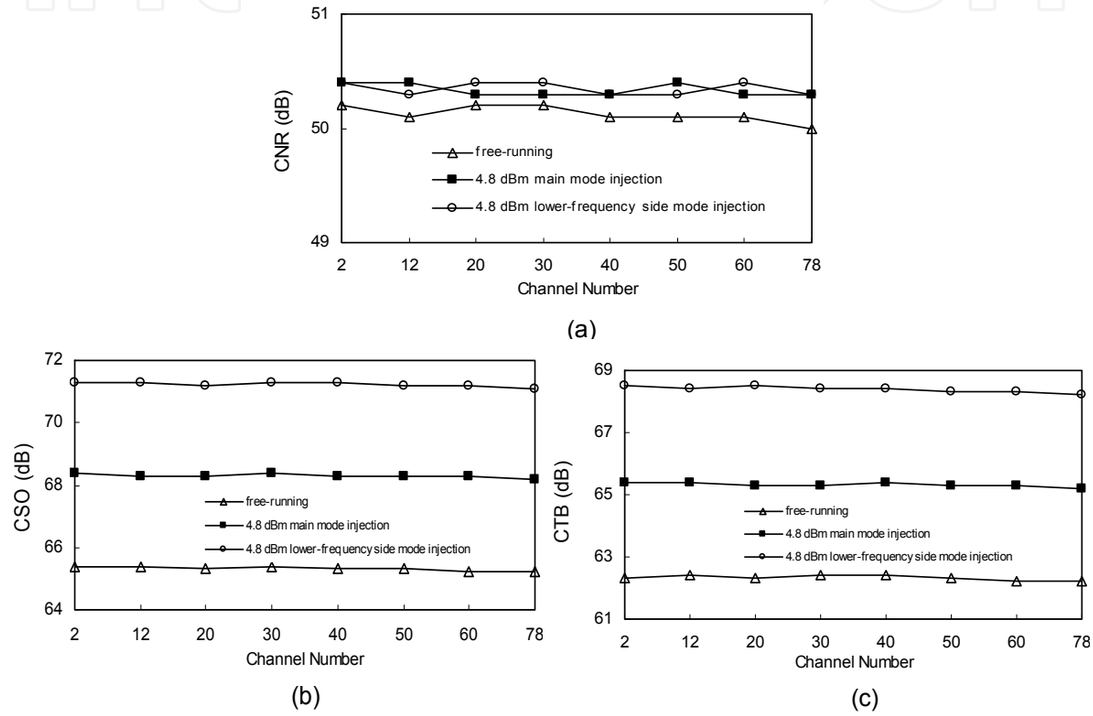

Fig. 8. Measured (a) CNR, (b) CSO and (c) CTB values under NTSC channel number

3.4 Hybrid local light-injection and optoelectronic feedback techniques

In parallel with the light-injection techniques, optoelectronic feedback technique has been used in high-speed digital optical communication systems to improve bit error rate (BER) performance (Attygalle & Wen, 2006). This technique, which can greatly enhance the laser resonance frequency (Li et al., 1995), is therefore can be integrated with light-injection methods to assist the transmission of fiber optical CATV systems as presented in Fig. 9 (Lu et al., 2006).

Experimentally, with the assisting of main mode injection and optoelectronic feedback, the laser resonance frequency is further improved to 25.2 GHz. The laser resonance frequency, f_0, is given by:

$$f_0^2 = \frac{g_0 S}{4\pi^2 \tau_\rho} \tag{10}$$

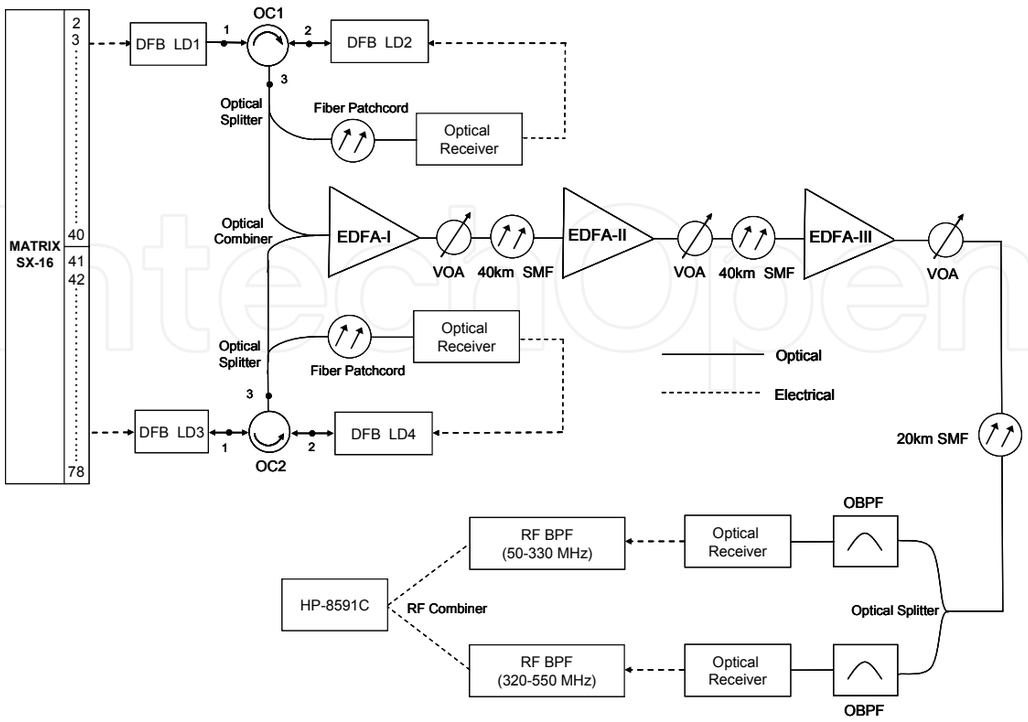

Fig. 9. Local light-injection and optoelectronic feedback techniques enhanced 100-km split-band directly modulated optical CATV system (Lu et al., 2006).

where g_0 is the gain coefficient, S is the photon density, and τ_p is the photon lifetime. Since f_0^2 is direct proportion to photon density, the increased photon density by the light-injection power will lead to a promotion of laser resonance frequency. Additionally, optoelectronic feedback techniques will further increase the stability of the laser, resulting in out-of-phase carrier re-injection. The re-injection can therefore assist the effect of the light-injection techniques, leading to an improvement of laser resonance frequency, as a result, presenting in an improvement of CSO/CTB values. The optoelectronic feedback techniques are hence an efficient method to enhance the performance of directly modulated optical CATV systems by promoting RF parameters.

4. Dispersions compensation schemes

Following with the modifications of direct modulation schemes and lightwave enhancement methods in fiber optical CATV systems, fiber chromatic dispersion is still another bottleneck needed to be solved out. Cascading CATV system with optical filter or a section of negative dispersion fiber (Lu et al., 2007) for example have been developed to overcome this issue. Since there is no useful modulating information in the redundant spectra, adding an optical filter to eliminate parts of these spectra not only can increase spectra efficiency but also can ameliorate the CSO/CTB performance. Similarly, cascading a section of negative dispersion fiber with a long-haul CATV system can also promote the system by eliminating the fiber chromatic dispersion. Consequently, the relative fiber dispersion compensation techniques are recorded and discussed in the following sections.

4.1 Downgrading dispersions by optical filter

Over a long-haul fiber transmission, fiber dispersion accumulates rapidly and leads to a worse system performance. To overcome this issue, utilizing optical filter to change the broad spectral linewidth into a narrow one has been demonstrated as a useful method in fiber optical transport systems (Lu et al., 2008). As presented in Fig. 10, the downstream optical signal was sent through a tunable optical band-pass filter (OBPF) and a Fabry-Perot (FP) etalon filter before received. The OBPF is applied to select the appropriate wavelength and the FP etalon filter is employed to narrow down the spectral linewidth as well as to compensate fiber dispersion.

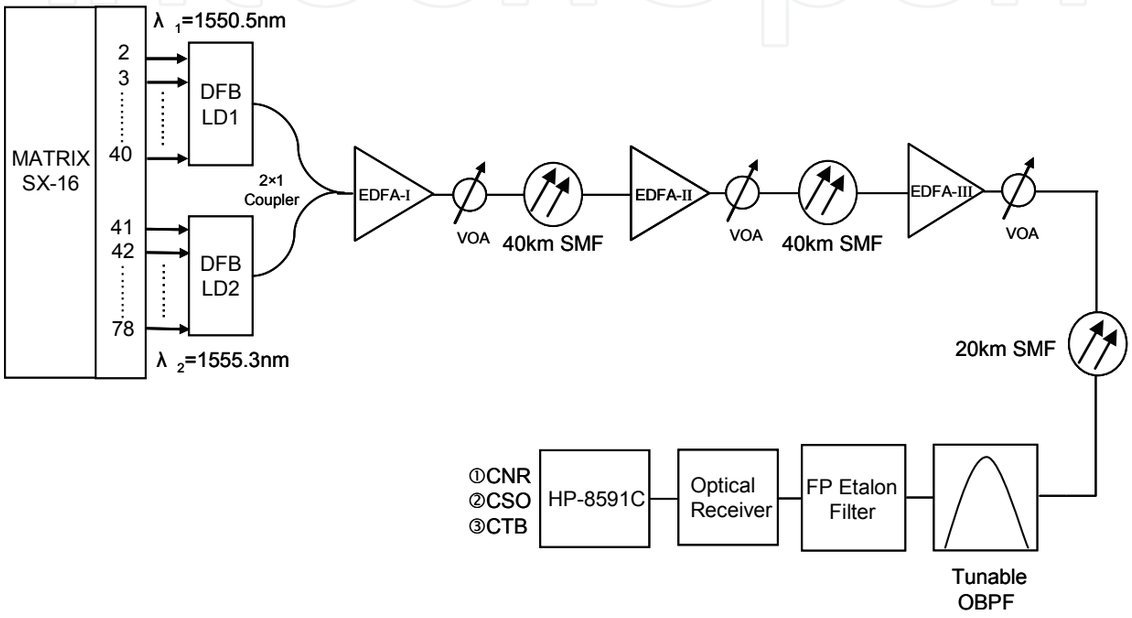

Fig. 10. Employing split-band technique and Fabry-Perot etalon filter to improve directly modulated fiber optical CATV system (Lu et al., 2008).

By eliminating the redundant spectra of optical signal, the spectral efficiency is enhanced and the dispersion is ameliorated resulting in better CSO/CTB performance. This optical filter is then worth deployed due to excellent optical characteristics such as sharp cutoff in the transmission spectrum. However, the wavelength misalignment between the selected optical wavelength and the optical filter will change optical power level launched into the fiber and degrade system performances. To avoid the wavelength misaligned by thermal effect, the filter needs to be utilized in a thermal package.

4.2 Dispersion compensated by special fiber

Different with cascading an optical filter to cut off optical spectral linewidth, adding a span of negative dispersion fibers, such as photonic crystal fiber (PCF), chirp fiber grating (CFG) and dispersion compensation fiber (DCF), into an optical CATV systems is experimentally demonstrated as another efficient method to compensate fiber dispersion (Ni et al., 2004). Fig. 11 for example demonstrates a 100-km optically amplified AM-VSB transmission system cascading with a span (3.6-km) of PCF disperion compensation fiber.

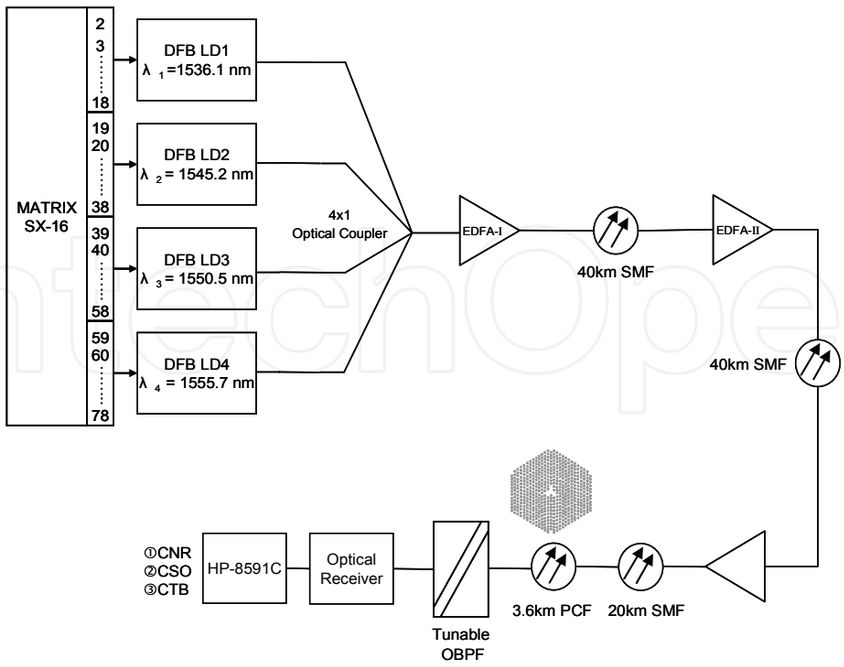

Fig. 11. A 100-km optically amplified AM-VSB transmission system with a length of PCF disperion compensation fiber (Lu et al., 2007).

In this system, the optical link with a transmission length of 100-km SMF has a total positive dispersion of 1700 ps/nm (17 ps/nm/km × 100 km). However, a length of 3.6-km PCF has a negative dispersion of -1710 ps/nm (-475 ps/nm/km × 3.6 km). By combining these two pieces together, the total dispersion is nearly eliminated (-10 ps/nm) leading to lower fiber-induced distortion and better CSO/CTB performance.

5. Extending applications of directly modulated fiber optical CATV systems

Following with an assistance of numerous techniques, the CATV service providers are able to offer high quality of CATV programs by cost effective optical fiber connection. Nevertheless, the potential of optical fiber is not fully utilized yet. Integrating other services, such as Internet access, WiMAX services and HDTV programs, with CATV transport systems would be quite useful to share the cost of deploying and maintaining optical fiber (Ying et al., 2007). Recently, passive optical networks (PONs) are promising way to obtain low cost and high capacity optical Internet access. DWDM in combination with PON has received considerable attentions due to its large capacity, network security, easy management, and upgrade- ability (Choi et al., 2005; Hann et al., 2004; Khanal et al., 2005). In parallel with the PON systems, radio-over-fiber (ROF) transport systems also present a potential to offer significant network flexibility, large transmission capacity and economic advantage to satisfy the increasing demand in wireless broadband services such as WiMAX (Masella & Zhang, 2006). Due to low attenuation and broad bandwidth characteristics of optical fiber, combining ROF and Internet access with CATV systems has subsequently attracted much attention to fully utilize the potential of optical fiber and to provide triple play services for clients. Fig. 12 for example presents a bidirectional HDTV/Gigabit Ethernet/CATV over DWDM-PON system. Services with 129 HDTV channels, 1.25 Gb/s

Gigabit Ethernet connection, and 77 CATV channels were successfully demonstrated over 40 km SMF links. Good performance of BER, CNR and CSO/CTB were achieved in this system.

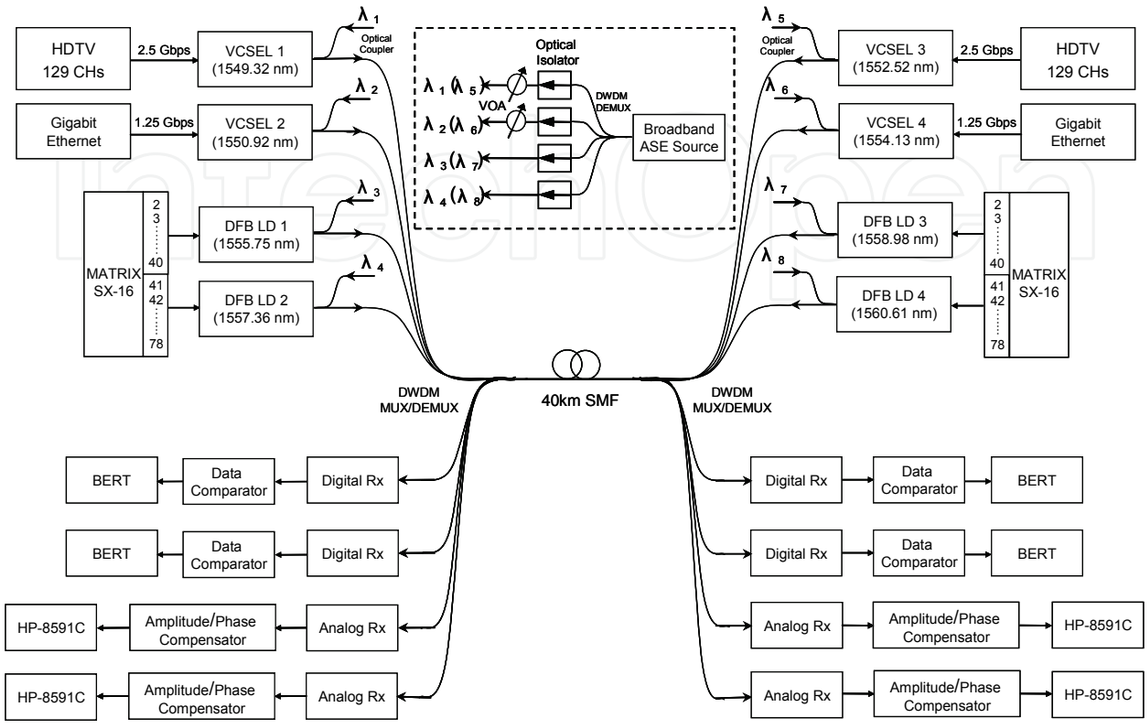

Fig. 12. HDTV/Gigabit Ethernet/CATV over bidirectional hybrid DWDM-PON (Lu et al., 2007).

6. Conclusion

Fiber optical CATV systems are recently enhanced by the introduction of 1550 nm technology. However the maximum transmission distance of the systems is still limited by RF parameters. Literarily, numbers of techniques such as split-band schemes, light-injection methods and dispersion compensation skills have been developed to extend the bottleneck in fiber optical CATV systems. Sharing full channel load from one LD to multiple LDs in split-band schemes has been demonstrated as an efficiency way to eliminate major part of CSO distortion from each optical band. Furthermore, improving laser resonance frequency and output power by light-injection techniques as well as compensating fiber dispersion by optical filters or by negative dispersion fiber are also presenting an advanced assistance in such systems. All of these techniques make a possibility to deploy a long-haul and cost-effective CATV system by direct modulation scheme. The main problem is that such systems do not fully utilize the potential of optical fiber. There is still plenty of capacity in fiber link waiting for people to dig out. As a result, combining fiber optical CATV systems with other applications, such as Internet access and WiMAX services, are discussed popularly in literature. The applications and characteristics of the mentioned techniques as well as the future directions of directly modulated fiber optical CATV system are consequently analyzed and illustrated in this chapter.

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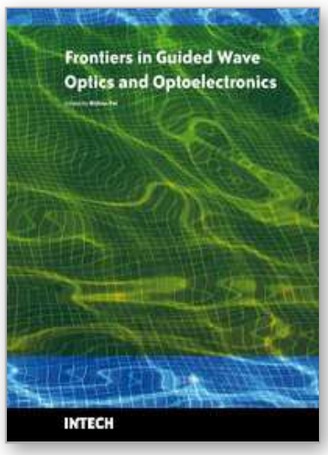

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As the editor, I feel extremely happy to present to the readers such a rich collection of chapters authored/co-authored by a large number of experts from around the world covering the broad field of guided wave optics and optoelectronics. Most of the chapters are state-of-the-art on respective topics or areas that are emerging. Several authors narrated technological challenges in a lucid manner, which was possible because of individual expertise of the authors in their own subject specialties. I have no doubt that this book will be useful to graduate students, teachers, researchers, and practicing engineers and technologists and that they would love to have it on their book shelves for ready reference at any time.

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