行政院國家科學委員會專題研究計畫成果報告

波分多工被動光纖網路和光纖微波系統中的瑞利背向散射噪音模型,分析,及緩和研究

Rayleigh Backscattering Noise Modeling, Analysis and Mitigation for DWDM Passive Optical Networks and Radio-over-Fiber Networks

計畫編號：97-2221-E-009-038-MY3
執行期限：98 年 8 月 1 日至 99 年 7 月 31 日
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一、中文摘要

現在的有線網路基於光纖到戶(FTTH)技術可以給用戶提供巨大的帶寬服務，但是對於漫遊連接就不夠靈活。因此，結合有線和無線服務在單一未來高帶寬接入網路可以使成本減低，同時滿足固定用戶和移動用戶的需求。這種混合接入網路可以由光纖微波(ROF)和波分復用被動光網路(WDM-PON)來實現。

在第一期(97-98)報告中我們已說明瑞利背向散射(Rayleigh backscattering)干擾噪音是載波分佈混合光接入網路的重要限制因素之一。由於之前的瑞利背向噪音模型具有不同的限制，我們成功地研究一個易實現，可有效操作的新型模型。我們已經進行了瑞利反向散射所產生的干涉噪音作理論分析。我們也對正交頻分複用(OFDM)技術進行了瑞利背向散射干擾噪音的實驗分析，成功獲得 OFDM 信號在不同瑞利噪音之下的特性。

本期報告將分成二部分:(1)我們提出新型的單邊帶過制載波(SSB-CS)信號，實驗結果顯示這種新的光調變格式具有極高的瑞利背向散射噪音容差值。(2)我們更提出及實驗了一個混合接取網路。利用暗歸零碼(DRZ)和二相移相键控(BPSK)分別作有線和無線應用，再通過調變下行訊號以產生上行信號，可以實現波長重用，並且進一步減少接取網路的成本。

關鍵詞：瑞利背向散射噪音緩和，被動光網路，光纖微波

Abstract

Today's wired networks based on fiber to the home (FTTH) access technologies provide huge bandwidth to users but are not flexible enough to allow roaming connections. Therefore, the integration of wired and wireless services for future access networks will lead to convergence of ultimate high bandwidth for both fixed and mobile users in a single, low cost platform. This can be accomplished by using radio-over-fiber (ROF) systems and wavelength division multiplexed passive optical network (WDM-PON) to provide wireless and wired applications.

In the first mid-term report, we have discussed that Rayleigh backscattering (RB) interferometric beat noise is considered as one of the most limiting factors for the carrier-distributed FTTH and ROF access networks. Due to different limitations of previous Rayleigh noise modeling, a novel modeling approach that can be easily realized and used efficiently to study the performance of noise mitigation has been successfully developed. We also discussed different RB performances of the orthogonal frequency division multiplexed (OFDM) PON networks

and successfully demonstrated a signal remodulation OFDM long reach (LR)-PON.

In this second mid-term report, (1) we will propose and investigate the RB noise reduction by using single sideband carrier suppressed (SSB-CS) modulation scheme. Experimental results show that the RB tolerance can be improved due to the reduced spectral overlap between the uplink signal and the RB noises. (2) We also propose and demonstrate a signal remodulated wired/wireless network. Dark-return-to-zero (DRZ) and binary-phase-shift-keying (BPSK) signals are used for the downstream wired and wireless broadcast respectively. The downstream signal will be remodulated to produce the upstream non-return-to-zero (NRZ) signal. Hence cost can be reduced by wavelength reuse.

Keywords: Rayleigh noise mitigation, Passive optical network, Radio-over-fiber

二、緣由與目的

In a wavelength division multiplexed (WDM) network, one of the most critical issues is the cost of the laser source used in the cost-sensitive subscriber side where the wavelengths for subscribers should be precisely aligned with an associated WDM link. Recently, passive optical network (PON) architecture with centralized light source (CLS) has been proposed to reduce the cost by removing the laser source from the subscriber side. This can be achieved by employing a wavelength insensitive reflective modulator at the customer optical networking unit (RONU) together with a seed light provided from the central office (CO) for wavelength addressing. However, a loop-back network will suffer from the interferometric noise caused by Rayleigh backscattering (RB), which interferes with the uplink signal at the receiver (Rx) at the CO. Several methods have been proposed to improve the system performance, such as using a dual-feeder fiber approach together with a novel detuned filtering and spectral broadening scheme; using phase-modulation-induced spectral broadening and offset optical filtering scheme; and using wavelength shifting in a cascade modulators. However, the methods mentioned above either need to install new fibers or are not power-efficient for the power-budget-sensitive PON (more than half of the uplink power will be filtered out by the offset filtering schemes or high insertion loss in the cascade modulator scheme). In this mid-term report, we first propose and investigate the RB noise reduction by using a dual-parallel Mach-Zehnder modulator (DP-MZM) as the RONU. By employing single sideband-carrier suppressed (SSB-CS) modulation scheme, the RB tolerance can be improved due to the reduced spectral overlap between the uplink signal and the RB noises. Both dominant contributions of RB: Carrier-Rayleigh backscattering (CB) and Signal-Rayleigh backscattering (SB) were experimentally characterized, for the first time, when using a DP-MZM as a RONU.

Previously proposed wired/wireless networks require precise optical filtering, or complex modulator structure. In the second part of this mid-term report, we will discuss a signal remodulated wired/wireless access network using a Mach-Zehnder modulator (MZM) and a phase modulator (PM) at the head-end (HE) and a reflective semiconductor optical amplifier (RSOA) as a colorless modulator in the optical networking unit/remote antenna unit (ONU)/(RAU). Dark-return-to-zero (DRZ) and binary-phase-shift-keying (BPSK) signals are used for the downstream PON and wireless broadcast respectively. The downstream signal will be remodulated to produce the upstream non-return-to-zero (NRZ) on-off keying (OOK) signal.

三、研究成果

Recent achievement of OFDM PON has been presented in **<u>CLEO’08 post-deadline paper</u>** in USA [1]. The achievements of the project have generated invited paper, invited talks and book chapter. We are invited to present our research achievements and impact of the FTTH for Taiwan in the Special Issue of the **<u>IEEE LEOS Newsletter</u>** about FTTx [2]. We has also been invited to contribute a **<u>Book Chapter</u>** in “Optical

Access Networks and Advanced Photonics: Technologies and Deployment Strategies," edited by I. P. Chochliouros and G. A. Heliotis, IGI Global Publishing [3]. It presents a comprehensive overview of emerging optical access network solutions to efficiently meet the anticipated growth in bandwidth demand. Our results and achievement in long-reach PON has been cited by Ref/Text Book: "Next-Generation FTTH Passive Optical Networks: Research towards unlimited bandwidth access," edited by Josep Prat, Springer, 2008. We are also invited to present our researches of FTTx in international conferences, such as:

- IEEE Photonics Society Annual Meeting 2010 (formerly LEOS Annual Meeting) in USA [4],
- Photonic West 2009 in USA [5],
- International High Speed Intelligent Communication 2010 (HSIC 2010) in Singapore [6],
- OECC 2009 in Hong Kong [7].

We have summarized the main achievements of the second year in this project as follow:

(1) RB noise reduction by using SSB-CS modulation.

(2) A signal remodulated wired/wireless network using DRZ wired and BPSK wireless signals.

(1) RB noise reduction by using SSB-CS modulation

Fig. 1.1 illustrates the Rayleigh backscattering (RB) contributions in a passive optical network (PON) architecture using centrally distributed carrier and reflective optical networking unit (RONU). The centralized light source (CLS) distributed from the central office (CO) and passes through a single feeder fiber towards the RONU to generate the uplink signal. There are two contributions to RB, which generated by the intrinsic phenomenon in fiber propagation. The two contributions will beat with the uplink signal to generate interferometric noise at the receiver (Rx) inside the CO. The first contribution, carrier-generated RB (CB), is generated by the back-reflection of the CLS seeding to the RONU. The second contribution, signal-generated RB (SB), is generated by the back-reflection of the uplink signals at the output of the RONU [8-11]. The backscattered light re-enters and is re-modulated by the RONU, then launched towards the CO Rx.

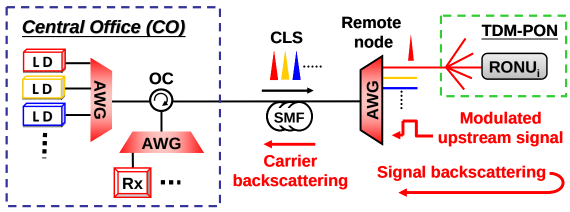

Fig. 1.1 RB contributions in a carrier distributed hybrid WDM-TDM PON architecture with RONU.

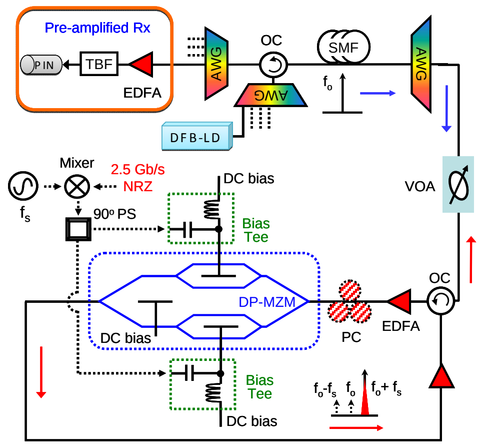

Fig. 1.2. Proposed carrier distributed PON using dual parallel-MZM (DP-MZM) as RONU. EDFA: erbium doped fiber amplifier, TBF: tuneable bandpass filter, VOA: variable optical attenuator, OC: optical circulator, PC: polarization controller, PS: phase shifter, 90° PS: 90° hybrid power splitter.

Fig. 1.2 shows the experimental setup of the fully passive carrier distributed PON using dual-parallel Mach-Zehnder modulator (DP-MZM) as the RONU. A distributed feedback-laser diode (DFB-LD) set at 1548.54 nm (f_0) was used as a CLS. The CLS was transmitted through 25 km or 75 km standard single mode fiber (SMF) towards the RONU, via an arrayed waveguide grating (AWG) (Gaussian shaped, 3-dB width of 50 GHz). There is no active component between the CO and the ONU, and the carrier distributed PON is fully passive. A variable optical attenuator (VOA) was used to emulate the PON split-ratio. In the colorless ONU, a loop-back configuration was achieved by an optical circulator (OC). A polarization controller (PC) was used to control the polarization state to maintain the optimum modulation of our proposed DP-MZM. The DP-MZM was commercially available with modulation speed of 12 GHz. The baseband 2.5 Gb/s non-return-to-zero (NRZ) data at pseudo random binary sequence (PRBS) 2^{31}-1 was up-converted via a radio frequency (RF) mixer with an electrical sinusoidal signal at frequency f_s (10 GHz) generated by a RF signal synthesizer. 2.5 Gb/s upstream data was used due to the bandwidth limitation of the mixer. The up-converted NRZ data was then split into two paths by a 90 degree hybrid power splitter (90^o PS) before being launched into the DP-MZM. The DP-MZM was driven in-phase and quadrature-phase, at arm 1 and arm 2 respectively, by the up-converted NRZ data with proper DC biases. Then the optical SSB-NRZ can be optimized by adjusting the driving voltage of arm 3. Erbium doped fiber amplifiers (EDFA) were used in the ONU to compensate the losses of the fiber transmission. Cost can be reduced by integrating the SOA with the semiconductor modulator. The uplink signal was then sent back to the CO through the same SMF. An optical pre-amplified Rx at the CO, consisted of an EDFA, a tunable bandpass filter (TBF) and a PIN, was used to receive the uplink signal. No dispersion compensation was used in the experiment.

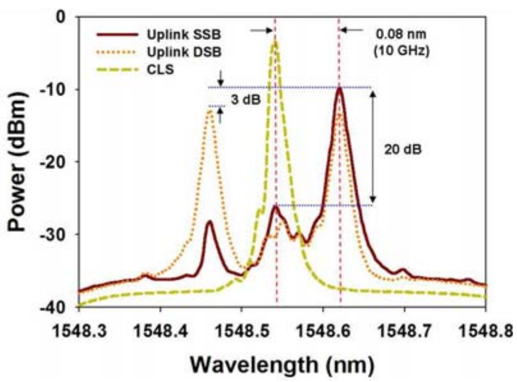

Fig. 1.3. Measured optical spectra. Solid line: SSB-CS uplink signal. Dotted line: DSB-CS uplink signal. Dashed line: centralized light source (CLS).

Fig. 1.3 shows the optical spectra measured by an optical spectrum analyzer with resolution of 0.01 nm. Dashed line is the distributed CLS at wavelength of 1548.54 nm measured at the input of the DP-MZM. Solid line and dotted line are the single sideband carrier suppressed (SSB-CS) and double sideband (DSB)-CS NRZ modulated uplink signals with RF driven at f_s = 10 GHz measured at the output of the DP-MZM. We can observe that the SSB-CS signal can save ~ 3 dB power when compared with the DSB-CS signal. This implies that the split-ratio of the PON could be improved when compared with the DSB-CS modulation with offset optical filtering. For SSB-CS uplink signal, the power ratios of the upper sideband to the lower sideband and center wavelength are > 20 dB. Since the RB tolerance depends on the interferometric beat noise falling within the Rx bandwidth, the RB tolerance of the SSB-CS modulation can be significantly improved due to the reduced spectral overlap with the CLS.

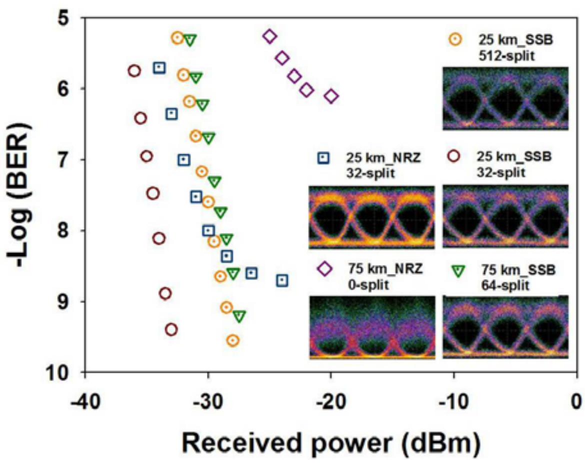

Fig. 1.4. BER performances of uplink SSB-NRZ (case 1) and conventional NRZ (case 2) signals with different split ratio in the transmission link. Insets show the corresponding eye diagrams.

Here, the split-ratio of our proposed scheme was also investigated and compared. Fig. 1.4 shows the BER performances of the SSB-CS NRZ with f_s=10 GHz and the conventional NRZ signals with different split-ratio in the transmission link, in the loop-back network as shown in Fig. 1.2. The results show that the power penalties of SSB-CS NRZ signals were significantly improved when compared to conventional NRZ signal. The corresponding eye diagrams are shown in the insets. For SSB-CS NRZ signal, high split-ratio of 512 was achieved after transmission of 25 km SMF; and also can reach up to 64-split after transmission of 75 km SMF. For conventional NRZ signal, error-floor appears when split-ratio of 32 after 25 km SMF; and the signal can hardly be detected after 75 km SMF transmission.

(2) Rayleigh backscattering analysis of OFDM signal

Recently, end users not only demand high data rate and secure broadband access, but also require high mobility connections, enable them to have broadband and Internet services outside building and even on public transport. Wired/wireless access networks have been proposed. In the future, high frequency carriers (≥60 GHz) are required to carry high data rate wireless signals. However, due to the relatively high atmospheric attenuation in the high frequency band, small cells (picocells) are used. To cover the same area, using picocells mean that many base stations (BSs) are required to provide sufficient network coverage. Because of this, colorless remote antenna unit (RAU) with centralized optical carrier distribution [12-20] could be a promising cost-effective candidate. Here, we demonstrate a signal remodulated wired/wireless access network using a Mach-Zehnder modulator (MZM) and a phase modulator (PM) at the head-end (HE) and a reflective semiconductor optical amplifier (RSOA) as a colorless modulator in the ONU/RAU. Dark-return-to-zero (DRZ) and binary-phase-shift-keying (BPSK) signals are used for the downstream PON and wireless broadcast respectively. The downstream signal will be remodulated to produce the upstream non-return-to-zero (NRZ) on-off keying (OOK) signal.

Fig. 2.1(a) shows the proposed architecture of the wired/wireless network. A continuous wave (CW) was first launched into a single-drive balanced MZM for DRZ (first channel) generation. The DRZ will be used for PON application. The MZM was driven by a differentially precoded 10 Gb/s NRZ data (D'_1, where 'prime' denotes differentially precoded) with amplitude of $2V_\pi$. The MZM was biased at a transmission minimum. The NRZ drive voltage switched the MZM towards the two adjacent maxima. When there is a transition from low-to-high or high-to-low in the applied NRZ drive voltage, the output state of the MZM is swept from a maximum, through a minimum, to an adjacent maximum, so generating a dark optical pulse. This is similar to differential phase shift keying (DPSK) generation, but the data is encoded onto the intensity instead of the phase of the optical carrier. Then, the DRZ signal was launched into a PM for the second channel modulation. The phase information between the dark pulses should be removed to encode the second channel. To rewrite the phase information onto the optical signal between the dark pulses, $D'_1 \oplus D'_2$ was applied to the PM, where $\oplus$ is the exclusive-OR (XOR) logic operation. Using the fact that $D'_1 \oplus D'_1 = 0$, and $0 \oplus D'_2 = D'_2$, the phase information between the DRZ pulses was rewritten and only D'_2 remained in the phase for wireless broadcast application. The time alignment between the two data channels should be controlled. Hence, at the output of the HE, the downstream signal carrying DRZ and DPSK was generated, as shown in Fig. 2.1(b). The signal was transmitted through the feeder fiber via a pair of arrayed waveguide gratings (AWGs) (Gaussian shaped, 3-dB bandwidth of 50 GHz). At the ONU/RAU, 10% the optical power was launched to a 10 GHz optically pre-amplified Rx_1 to detect the DRZ signal (D_1). Then 10% of the downstream signal was launched to a 1-bit delayed interferometer (DI) (for DPSK demodulation) and received by a 10 GHz optically pre-amplified ac-coupled Rx_2. At the output of the Rx_2, an ac-coupled NRZ data (D_2) was obtained. The NRZ data was up-converted (mixed with a 60 GHz electrical sinusoidal signal) for wireless broadcast. The rest of downstream optical signal was then launched into the RSOA, which was applied by a 2.5 Gb/s NRZ data at PRBS 2^{31}-1 to produce the upstream signal. The upstream signal was detected by a 2.5 GHz optically pre-amplified Rx_3 at HE.

Fig. 2.2 shows the bit-error rate (BER) measurements of the downstream and upstream signals at back-to-back (B2B) and after SMF transmission, with the corresponding eye diagrams after transmission (insets Fig. 2.2).

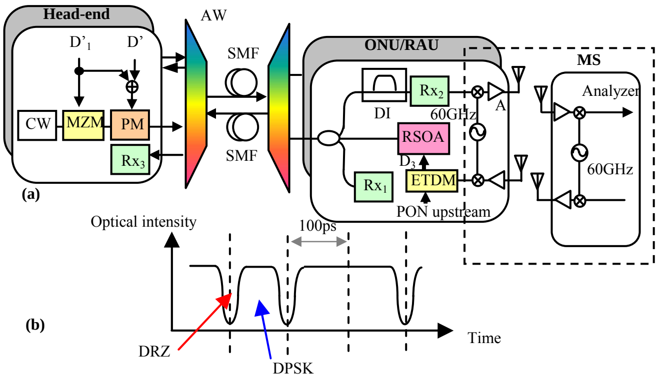

Fig. 2.1(a) Architecture of the wired/wireless access network. MZM: Mach-Zehnder modulator, PM: phase modulator, SMF: single mode fiber, AWG: arrayed waveguide grating, DI: delayed interferometer, A: RF amplifier, RAU: remote antenna unit, MS: mobile station. ETDM: electrical time division multiplexer. (b) Schematic time trace of the downstream signal carrying DRZ and DPSK.

Error free operations are observed in each case with clear open eyes. We measured about 1.7 dB and 2 dB power penalties in the downstream DPSK (at Rx_2) and DRZ (at Rx_1) signals respectively. The power penalties of the DPSK and DRZ signals are due to fiber chromatic dispersion. Poorer Rx sensitivity of DRZ signal when compared with DPSK and OOK signals is due to the high residual optical background between the DRZ pulses. We observed < 1 dB power penalty in the upstream remodulated OOK signal (at Rx_3) since the data rate of upstream signal is 2.5 Gb/s. Negligible power penalty was observed if the downstream DPSK and DRZ were turned off, and CW signal was used to the RSOA to generate the upstream OOK signal.

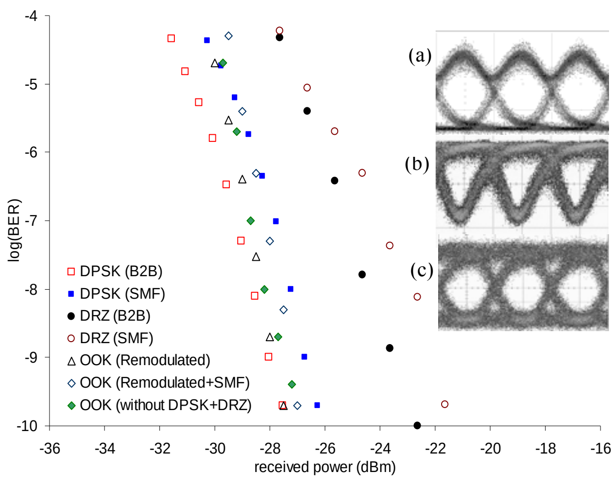

Fig. 2.2. BER measurements. Insets: eyes of (a) 10Gb/s demodulated DPSK (at Rx_2), (b) 10Gb/s DRZ (at Rx_1), and (c) remodulated 2.5Gb/s OOK (at Rx_3) after transmission.

Numerical simulations were performed for the BPSK (10 Gb/s data on 60 GHz carrier) signal analysis. Two different optical launched powers to the Rx_2 inside the RAU (-26 dBm and -23 dBm) were studied. -26 dBm launched power was chosen due to the error-free demodulated DPSK condition as shown in Fig. 2.2. RF amplifiers (A) (20 dB gain, noise figure 3 dB) were used in the RAU and the MS respectively. In the analysis, the antennas were removed; and a RF attenuator was used to connect the RAU and MS to emulate the atmospheric loss in the transmission path. In real situation, the attenuation due to atmospheric gases for a standard atmosphere at 60 GHz band is 10-20 dB/km. Fig. 2.3 shows the Q (dB) of the down-converted BPSK signal received at the MS under different attenuations. The results show that the atmospheric attenuation can up to 50 dB when the optical input power to the RAU was -26 dBm

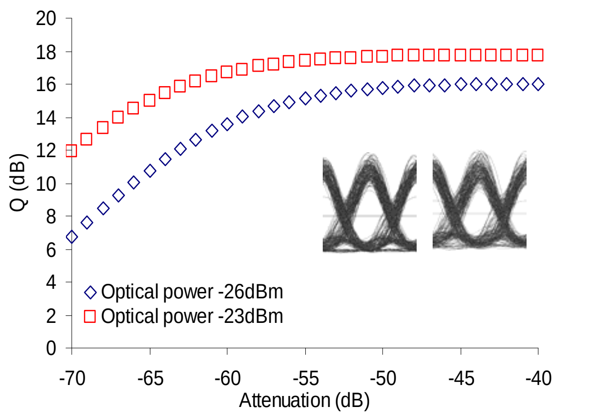

Fig. 2.3: Simulated Q (dB) of the down-converted BPSK signal at the MS under different attenuations between the RAU and the MS. Insets: simulated eyes of demodulated BPSK at MS when (a) Q=17.5dB (optical power at -23dBm) and (b) Q=16dB (optical power at -26 dBm).

四、結論

The above researches have fruitful achievements and results have been published in several international journal and conference papers, invited papers and talks. The second year project mid-term report was divided into two sections: (1) Using DP-MZM to mitigate RB noises in a fully passive bidirectional carrier distributed PON was demonstrated. By employing SSB-CS modulation, the RB tolerance is efficiently improved by 6.5 and 3.5-dB for CB and SB, respectively, when compared with the conventional NRZ signal. A high spilt-ratio of 512 and 64 was achieved in the SMF transmission of 25 km and 75 km respectively. The results show that our proposed scheme could be a potential candidate for RB mitigation. (2) We demonstrated a signal remodulated wired/wireless access network using RSOA as colorless modulator with the capability of wireless signal broadcast. DRZ and BPSK signals were used for the downstream PON application and wireless broadcast respectively. The upstream NRZ signal was generated by signal remodulation. 1.7 dB and 2 dB power penalties were measured in the downstream DPSK and DRZ signals respectively. We observed < 1 dB power penalty in the upstream remodulated OOK signal.

The above results will provide a solid foundation for the final year research project.

五、發表文獻

[1] **C. W. Chow**, et al., "Demonstration of High Spectral Efficient Long Reach Passive Optical Networks using OFDM-QAM," ***CLEO,* Postdeadline Paper**, CPDB7, San Jose, USA, 2008

[2] C. H. Yeh, **C. W. Chow**, Y. M. Lin, D. Z. Hsu, and S. Chi "Recent Research on Fiber Access Systems for FTTH Networks in Taiwan" Invited paper, ***IEEE LEOS Newsletter***, vol. 22, no. 2, pp. 15-19, 2008

[3] **C. W. Chow,** Chapter V: "Broadband Optical Access using Centralized Carrier Distribution," *Optical Access Networks and Advanced Photonics: Technologies and Deployment Strategies,* edited by I. P. Chochliouros and G. A. Heliotis, IGI Global Publishing (ISBN: 978-1-60566-707-2).

[4] **C. W. Chow**, "Long-reach DWDM PON," Invited talk, *IEEE Photonics Society Annual Meeting 2010*, Denver, USA (Nov. 7-11, 2010)

[5] S. Chi, C. H. Yeh, **C. W. Chow**, "Broadband access technology for passive optical network," *Proc. of SPIE*, vol. 7234, 723408-1, 2009 (Invited Paper)

[6] **C. W. Chow**, et al "Long-reach PONs for Next Generation Access Networks," *International High Speed Intelligent Communication 2010 (HSIC 2010)*, Singapore (May 13-14, 2010)

[7] **C. W. Chow**, "Long Reach WDM-PON," Invited Workshop Speaker, *OptoElectronics and Communications Conference (OECC'09)*, Hong Kong (July 13, 2009)

[8] G. Talli, **C. W. Chow**, P. D. Townsend, "Modeling of modulation formats for interferometric noise mitigation," *Journal of Lightwave Technology*, vol. 26, pp. 3190-3198, 2008 (SCI)

[9] **C. W. Chow**, G. Talli, A. D. Ellis, and P. D. Townsend, "Rayleigh noise mitigation in DWDM LR-PONs using carrier suppressed subcarrier-amplitude modulated phase shift keying," *Optics Express*, vol. 16, pp. 1860-1866, 2008 (SCI)

[10] **C. W. Chow**, G. Talli, and P. D. Townsend, "Rayleigh Noise Reduction in 10-Gb/s DWDM-PONs by Wavelength Detuning and Phase Modulation Induced Spectral Broadening," *IEEE Photonics Technology Letters*, vol. 19, no. 6, pp. 423, 2007 (SCI)

[11] **C. W. Chow**, C. H. Yeh, C. H. Wang, F. Y. Shih, and S. Chi "Rayleigh Backscattering Performance of OFDM-QAM in Carrier Distributed Passive Optical Networks," *IEEE Photonics Technology Letters*, vol. 20, pp. 1848-1850, 2008 (SCI)

[12] **C. W. Chow**, "Wavelength Remodulation Using DPSK Down-and-Upstream With High Extinction Ratio for 10-Gb/s DWDM-Passive Optical Networks," *IEEE Photonics Technology Letters*, vol. 20, pp.12-14, 2008 (SCI)

[13] **C. W. Chow**, C. H. Yeh, "Signal remodulation without power sacrifice for carrier distributed hybrid WDM-TDM PONs using PolSK," *Optics Communications*, vol. 282, pp. 1294-1297, 2009 (SCI)

[14] C. H. Yeh, **C. W. Chow** and S. Chi, "Using 10 Gb/s remodulation DPSK signal in self-restored colorless WDM-PON system," *Optical Fiber Technology*, in press, 2009 (SCI)
[15] C. H. Yeh and **C. W. Chow**, "Utilization of Four WDM Channels with Signal Remodulation of OFDM-QAM for 10-Gb/s Uplink Passive Optical Networks," Optics Communications, accepted, 2009 (SCI)
[16] **C. W. Chow**, C. H. Yeh, C. H. Wang, F. Y. Shih and S. Chi, "Signal remodulation of OFDM-QAM for long reach carrier distributed passive optical networks," *IEEE Photonics Technology Letters*, vol. 21, pp. 715-717, 2009 (SCI)
[17] **C. W. Chow**, et al, "Mitigation of Signal Distortions using Reference Signal Distribution with Colorless Remote Antenna Units for Radio-over-Fiber Applications," *Journal of Lightwave Technology*, vol. 27, pp. 4773-4780, 2009
[18] C. H. Yeh, **C. W. Chow**, et al, "Using four wavelength-multiplexed self-seeding Fabry-Perot lasers for 10 Gbps upstream traffic in TDM-PON," *Opt. Express*, vol. 16, pp. 18857-18862, 2008
[19] **C. W. Chow**, et al, "Signal Remodulation High Split-ratio Hybrid WDM-TDM PONs using RSOA-based ONUs," *Electronics Letters*, vol. 45. pp. 903-905, 2009
[20] **C. W. Chow**, et al, "Signal Remodulated Wired/Wireless Access using Reflective Semiconductor Optical Amplifier with Wireless Signal Broadcast," *IEEE Photonics Technology Letters*, vol. 21, pp. 1460-1462, 2009

可供推廣之研發成果資料表

■ 可申請專利　　□ 可技術移轉　　　　　　　　　　　　　日期：99年5月30日

國科會補助計畫	計畫：波分多工被動光纖網路和光纖微波系統中的瑞利背向散射噪音模型, 分析, 及緩和研究 計畫主持人：鄒志偉　計畫編號：NSC 97-2221-E-009-038-MY3 學門領域：光電
技術/創作名稱	Signal Remodulated Wired/Wireless Access using Reflective Semiconductor Optical Amplifier with Wireless Signal Broadcast
發明人/創作人	C. W. Chow, C. H. Yeh, and S. Chi
技術說明	In this investigation, we propose and demonstrate a signal remodulated wired/wireless network using reflective semiconductor optical amplifier (RSOA) as a colorless modulator in the optical networking unit (ONU) / remote antenna unit (RAU). Dark-return-to-zero (DRZ) and binary-phase-shift-keying (BPSK) signals are used for the downstream wired and wireless broadcast respectively. The downstream signal will be remodulated to produce the upstream non-return-to-zero (NRZ) signal.
可利用之產業及可開發之產品	產業：光纖通訊 產品：混合接取網路與光纖系統
技術特點	我們提出使用一組調變器能產生暗歸零碼(DRZ)和二相移相键控(BPSK)分別用在有線和無線混合接取網路，再通過調變下行訊號以產生上行信號，可以實現波長重用，並且進一步減少接取網路的成本。
推廣及運用的價值	根據此發明加以商品化的產品將在成本上具有優勢。

※　1.每項研發成果請填寫一式二份，一份隨成果報告送繳本會，一份送　貴單位研發成果推廣單位（如技術移轉中心）。

※　**2.本項研發成果若尚未申請專利，請勿揭露可申請專利之主要內容。**

※　3.本表若不敷使用，請自行影印使用。