Dynamic Wavelength Hopping Scheme with AWG/Optical Switch Applied to Secure Un-compressed Video Transmission

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***Abstract*—In order to enhance confidentiality of wireless wavelength division multiplexing (WDM) networks, the proposed integrated arrayed waveguide grating (AWG) and optical switch is configured to implement wavelength hopping in current experiment. A pseudo-random noise generator (PRNG) algorithm was embedded with a pair of master-slave microprocessor (i.e., Arduino chips) to generate a time series of electrical signals for triggering optical switch and then the path of optical switch was randomly varied to change the space transmission of AWG router. As result, the varying wavelengths were assigned as authorized users' carrier to realize AWG/optical switch-based wavelength hopping scheme. The experimental results showed that the transmitted un-compressed high definition multimedia interface (HDMI) video stream was extracted correctly by photo-detector to protect against attacking by interceptor.**

Key index: Dynamic wavelength hopping; AWG and optical switch; Secure video transmission; Wavelength division multiplexing.

I. INTRODUCTION

Using air instead of optical fibers as the medium for the two-way information transmission of optical signals has recently attracted attention for use in wireless optical communication systems [1–2]. Improving the confidentiality of access networks has emerged as a critical problem in recent years. Optical code-division multiple-access (OCDMA) schemes have shown significantly to improve the robustness of optical networks toward malicious attack [3-5]. In order to achieve the confidential ability in wavelength division multiplexing (WDM) network, Chang et al. have published the basic theory of AWG/optical switch-based wavelength hopping and fundamental experiment for analog signal transmission over wired fiber transmission [6-7]. In current study, the extending experiment of secure un-compressed HDMI video stream was implemented that dynamic wavelength hopping scheme was proved possible and feasible configuration over wireless channel such as those executed over electrical domain of WiFi network.

II. PROPOSED WAVELENGTH HOPPING SCHEME

The proposed AWG/optical switch-based wavelength hopping is configured two major parts that a pseudo-random noise generator (PRNG) algorithm was embedded with a pair of master-slave microprocessor (i.e., Arduino chips) to generate a time series of electrical signals for triggering optical switch shown as Fig1. The other important part for microprocessor (i.e., Raspberry chip) shown in Fig 2 is performed un-compressed HDMI video stream to connect EOM for electrical/optical modulation shown as Fig 2. It was assumed that an un-authorized user (e.g., interceptor) employed N correlation filters to tap N channels in a public network [3-7]. Here, the number of N is also equal to the number of AWG ports.

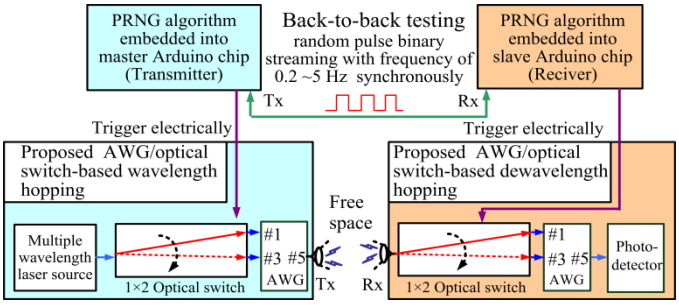


Fig.1. The PRNG algorithm embedded in master-slave Arduino chip for triggering AWG/optical switch-based wavelength hopping

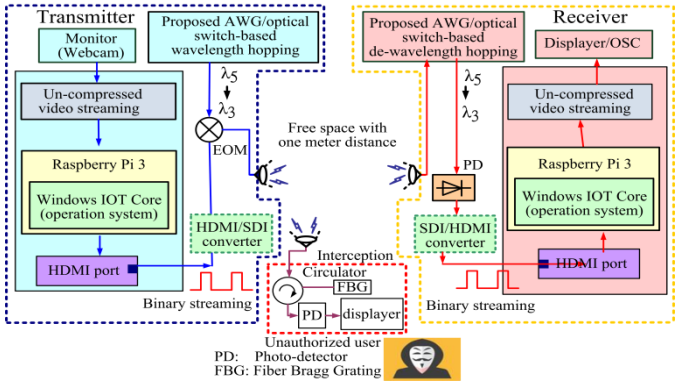
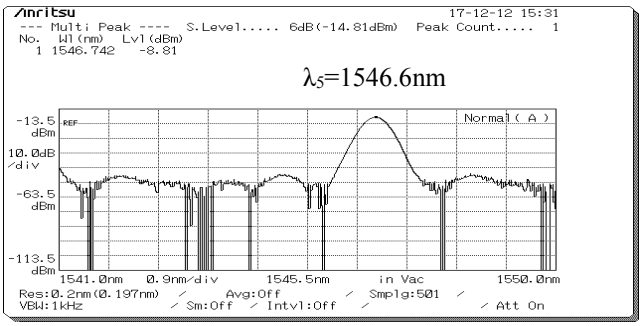


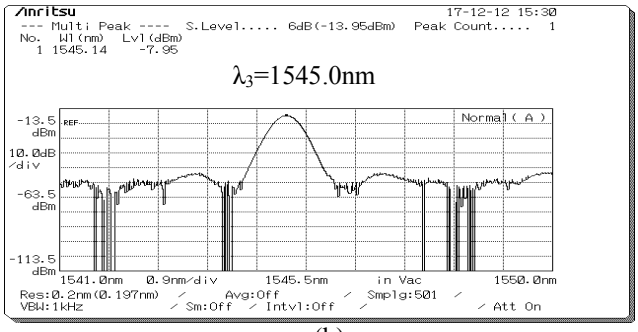
Fig.2. Un-compressed HDMI video stream embedded in Raspberry chip and integrate successfully electrical/optical modulation for proposed AWG/optical switch-based wavelength hopping

II EXPERIMENT OF WAVELENGTH HOPPING ON VIDEO STREAM

Different from previous experiment to further investigate the leakage effects caused by loser adjacent wavelength [7], the light source of wavelength λ_1~λ_8 change the transmission path to enter into input port of AWG from #1 to #3 resulting from optical switch active (i.e., referenced Fig.1). Hence, the output port #5 of AWG router is monitored wavelength hopping from λ_5=1546.6nm to λ_3=1545.0nm which assigned individual authorized user as carrier for the desired HDMI video stream of 1.485Gbps. For changing λ_1~λ_8 path to enter input port of AWG from #1 to #3, the Fig. 3(a) and (b) present the wavelength spectra of λ_5=1546.6nm and λ_3=1545.0nm monitored on output port #5 of AWG router by optical spectrum analyzer (OSA) while optical switch is bar (off) and cross (on) state, respectively.



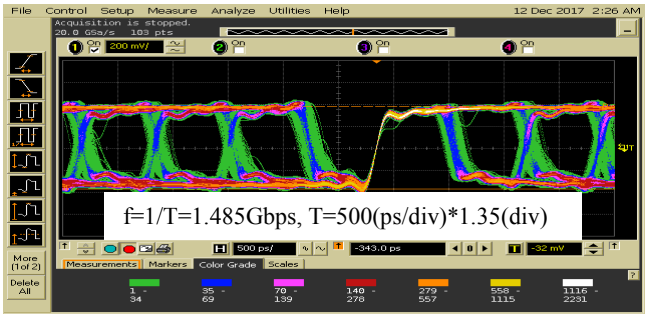
(a)



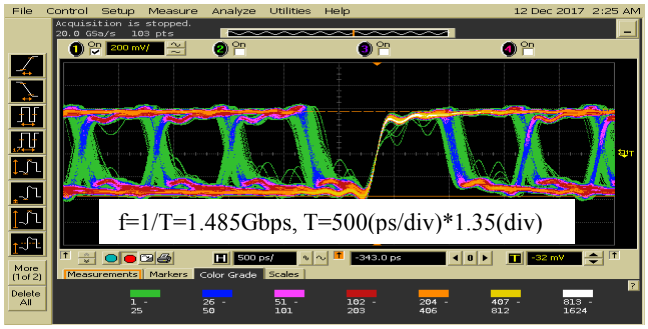
(b)

Fig. 3 Monitoring wavelength hopping on output port #5 of AWG router (a). λ_5=1546.6nm while optical switch bar (off) state. (b). λ_3=1545.0nm on the switch cross (on) state respectively caused by changing input port of AWG from #1 to #3

By monitoring with oscilloscope (OSC) configured behind photo-detector, the experimental results showed that the desired un-compressed video stream of 1.485Gbps is correctly retrieved from eye diagram in Fig.4 to prove feasible proposed dynamic wavelength hopping scheme.



(a)



(b)

Fig. 4. Retrieving correctly the desired un-compressed video stream of 1.485Gbps behind photo-detector (a). λ_5=1546.6nm while optical switch bar (off) state. (b). λ_3=1545.0nm on the switch cross (on) state respectively.

III. Conclusion

The proposed AWG/optical switch-based wavelength hopping scheme was configured with pseudo-random noise generator (PRNG) algorithm and embedded with a pair of master-slave microprocessor (i.e., Arduino chips) to generate a time series of electrical signals for triggering optical switch and result in the varying wavelengths assigned as authorized users' carrier to realize. By using OSA and the OSC equipment for monitoring measurement, the experimental results showed the desired un-compressed HDMI video stream of 1.485 Gbps was retrieved and identified correctly behind photo-detector while the wavelength hopping is been occurred. In near future works, the un-match effect of interceptor will be further analyzed on practical experiment to protect against interception and interference. In addition, the compressed video stream such as H.264/AVC video stream will be verified and implemented in the same proposed configuration by producing the interface of microprocessor (e.g., Raspberry chip) and electrical/optical modulator (EOM).

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Reference

[1] C.Y. Chen, H.H. Lu, Y.P. Lin, P.Y. Wu, K.H. Wu and W.Y. Yaug, "Full-duplex lightwave transport systems based on long-haul SMF and optical free-space transmissions," Optics Express, vol. 21, issue 20, pp. 23655-23661, Oct. 2013.

[2] H. L. Minh, Y. L. Yu, S.K. Liaw, H.Y. Hsu, W. C. Lu, and Z. Ghassemlooy, "DWDM bidirectional wavelength reuse optical wireless transmission in 2x80 Gbit/s capacity," 2013 2nd International Workshop on Optical Wireless Communications (IWOW), pp. 128-131, Newcastle upon Tyne, UK, Oct.21. 2013.

[3] T. H. Shake., "Security performance of optical CDMA against eavesdropping," J. IEEE J. Lightwave Technol., vol. 23, no. 2, pp. 655–670, Feb. 2005.

[4] Y.T. Chang, C.W. Tsailin, "Dynamic scrambling scheme of arrayed-waveguide grating-based encryptors and decryptors for protection against eavesdropping,"Computers and Electrical Engineering, vol.49, no. 1, pp.184-197, Jan. 2016.

[5] Yao-Tang Chang, Yih-Chuan Lin, "Dynamic Reconfigurable Encryption and Decryption with Chaos/M-Sequence Mapping Algorithm for Secure H.264/AVC Video Streaming over OCDMA Passive Optical Network," Multimedia tools and Application, vol.75, no. 16, pp.9837-9859, Aug. 2016.

[6] Y.T. Chang, Y.C. Lin, "The Scrambling Cryptography Implemented with Chaotic Sequence Trigger Optical Switch Algorithm in WDM Passive Optical Network," The 49th Annual IEEE International Carnahan Conference on Security Technology (ICCST 2015) pp. 259-262, Taipei, Taiwan, Sep. 21-24, 2015.

[7] Yao-Tang Chang, Hsu-Chih Cheng, Yih-Chuan Lin and Yu-Xiang Zheng. "The Design and Implementation of Scrambling Wavelength Hopping with AWG Router and Optical Switch over Secure WDM Network," Proceedings of Engineering and Technology Innovation, vol. 5, pp. 07-12, Dec. 2017.