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Novel CCTV security camera system using DWDM wavelength enhancement

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Abstract

We propose a new design of a security camera system that uses the dense wavelength division multiplexing wavelength enhancement, whereas increasing in channel capacity and security can be provided. The increasing in number of channel can be obtained by the increasing in wavelength density, while the security is introduced by the specific wavelength filter, which is operated by the central operator. The optical communication wavelength enhancement is reviewed. The advantage is that the proposed system can be implemented and used incorporating with the existed communication link in either wire/wireless system, where the human privacy can be provided, which is discussed in details.

Keywords: DWDM, security camera, CCTV, nano-waveguide, privacyprotection

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1. Introduction

Closed circuit televisions have been widely used in many areas of applications (William,2007; Davis and Valentine,2009;Jacobs,1992;Thomas,1992; and Boulton,1989), where one of them uses closed circuit television(CCTV) for surveillance (Klauser,2009 and Welsh and Farrington, 2004), especially, crime surveillance. Although, the CCTV technology is concreted and well established, the development is still required. In this paper, we present the technique that can be used to increase channel capacity, while the security is also installed. The advantages of the proposed system are (i) the system can provide the increasing channel capacity by using optical technique dense wavelength division multiplexing(DWDM) and (ii) the security concept can be provided by using the specific wavelength which is required the specific filter to retrieve the required signals (Joseph and Harper,1997). This means that the human personnel privacy can be protected form the other parties, however, the specific case can be retrieved by using the known code, i.e. filter. Firstly, the multi wavelength sources are generated by using a Gaussian pulse propagating within a microring resonator system. Gaussian soliton is become a very attractive tool in the area of light investigation, whereas the simple system arrangement can be used to form the soliton behavior

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within the medium for various investigations. Many research works have reported in both theoretical and experimental works using a common Gaussian pulse for soliton study (Deng and Guo, 2007). Recently, Yupapin and Suwancharoen (Yupapin and Suwancharoen, 2007) have reported the interesting results of light pulse propagating within a nonlinear microring device, where the transfer function of the output at resonant condition is derived and studied. They found that the broad spectrum of light pulse can be transformed to the discrete pulses. An optical soliton is recognized as a powerful laser pulse, which can be used to enlarge the optical bandwidth when propagating within the nonlinear microring resonator (Yupapin et al, 2008 and Pornsuwancharoen and Yupapin, 2009). Moreover, the superposition of self-phase modulation (**SPM**) soliton pulses, where either bright or dark (Kivshar and Luther-Davies, 1998) solitons can generate the large output power. For further reading, many earlier works of soliton applications in either theory or experimental works are found in a soliton application book by Hasegawa (Hasegawa, 2000).

Light from a monochromatic light source is launched into a ring resonator with constant light field amplitude (E_0) and random phase modulation as shown in Fig. 1, which is the combination of terms in attenuation (α) and phase(f_0) constants, which results in temporal coherence degradation. Hence, the time dependent input light field (E_{in}), without pumping term, can be expressed as (Takeshi and Kivshar, 1999)

$$E_{in}(t) = E_0 \exp^{-\alpha L + j\phi_0(t)} \qquad (1)$$

where L is a propagation distance(waveguide length).

We assume that the nonlinearity of the optical ring resonator is of the Kerr-type, i.e., the refractive index is given by

$$n = n_0 + n_2 I = n_0 + (\frac{n_2}{A_{eff}})P, \qquad (2)$$

where n_0 and n_2 are the linear and nonlinear refractive indexes, respectively. I and P are the optical intensity and optical power, respectively. The effective mode core area of the device is given by A_{eff}. For the microring and nanoring resonators, the effective mode core areas range from 0.10 to 0.50 μm^2 (Xu and Lipson, 2007)

When a Gaussian pulse is input and propagated within a fiber ring resonator, the resonant output is formed, thus, the normalized output of the light field is the ratio between the output and input fields ($E_{out}(t)$ and $E_{in}(t)$) in each roundtrip, which can be expressed as (Yupapin et al, 2007)

$$\left|\frac{E_{out}(t)}{E_{in}(t)}\right|^2 = (1-\gamma)\left[1 - \frac{(1-(1-\gamma)x^2)\kappa}{(1-x\sqrt{1-\gamma}\sqrt{1-\kappa})^2 + 4x\sqrt{1-\gamma}\sqrt{1-\kappa}\sin^2(\frac{\phi}{2})}\right] \qquad (3)$$

Equation (3) indicates that a ring resonator in the particular case is very similar to a Fabry-Perot cavity, which has an input and output mirror with a field reflectivity, (1-κ), and a fully reflecting mirror. k is the coupling coefficient, and $x = \exp(-\alpha L/2)$ represents a roundtrip loss coefficient, $\phi_0 = kLn_0$ and $\phi_{NL} = kL(\frac{n_2}{A_{eff}})P$ are the linear and nonlinear phase shifts, $k = 2\pi/\lambda$ is the wave propagation number in a vacuum. Where L and α are a waveguide length and linear absorption coefficient, respectively. In this work, the iterative method is introduced to obtain the results as shown in equation (3), similarly, when the output field is connected and input into the other ring resonators.

The input optical field as shown in equation (1), i.e. a Gaussian pulse, is input into a nonlinear microring resonator. By using the appropriate parameters, the chaotic signal is obtained by using equation (3). To retrieve the signals from the chaotic noise, we propose to use the add/drop device with the appropriate parameters. This is given in details as followings. The optical outputs of a ring resonator add/drop filter can be given by the equations (4) and (5).

$$\left|\frac{E_t}{E_{in}}\right|^2 = \frac{(1-\kappa_1) - 2\sqrt{1-\kappa_1}\cdot\sqrt{1-\kappa_2}\,e^{-\frac{\alpha}{2}L}\cos(k_n L) + (1-\kappa_2)e^{-\alpha L}}{1 + (1-\kappa_1)(1-\kappa_2)e^{-\alpha L} - 2\sqrt{1-\kappa_1}\cdot\sqrt{1-\kappa_2}\,e^{-\frac{\alpha}{2}L}\cos(k_n L)} \qquad (4)$$

and

$$\left|\frac{E_d}{E_{in}}\right|^2 = \frac{\kappa_1\kappa_2 e^{-\frac{\alpha}{2}L}}{1 + (1-\kappa_1)(1-\kappa_2)e^{-\alpha L} - 2\sqrt{1-\kappa_1}\cdot\sqrt{1-\kappa_2}\,e^{-\frac{\alpha}{2}L}\cos(k_n L)} \qquad (5)$$

where E_t and E_d represents the optical fields of the throughput and drop ports respectively. The transmitted output can be controlled and obtained by choosing the suitable coupling ratio of the ring resonator, which is well derived and described by reference (Fietz and Shvets, 2007). Where $\beta = kn_{eff}$ represents the propagation constant, n_{eff} is the effective refractive index of the waveguide, and the circumference of the ring is $L = 2\pi R$, here R is the radius of the ring. In the following, new parameters will be used for simplification, where $\phi = \beta L$ is the phase constant. The chaotic noise cancellation can be managed by using the specific parameters of the add/drop device, which the required signals at the specific wavelength band can be filtered and retrieved. $K_1$and K_2 are coupling coefficient of add/drop filters, $k_n = 2\pi / \lambda$ is the wave propagation number for in a vacuum, and the waveguide (ring resonator) loss is α = 0.5 dBmm^{-1}. The fractional coupler intensity loss is γ = 0.1. In the case of add/drop device, the nonlinear refractive index is neglected.

2. CCTV Security System using DWDM Wavelength Enhancement

From Figure 1, in principle, light pulse is sliced to be the discrete signal and amplified within the first ring, where more signal amplification can be obtained by using the smaller ring device (second and third ring). Finally, the required signals can be obtained via a drop port of the add/drop filter.

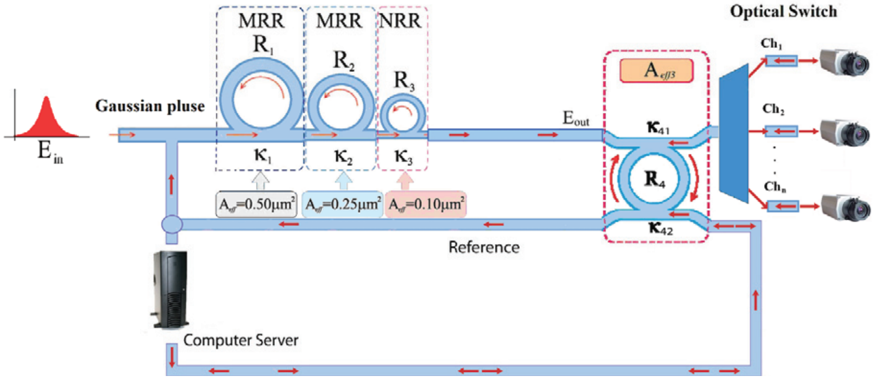

Figure 1. A schematic of a CCTV system, R_1 - R_3 are ring radii, κ_s: coupling coefficients, κ_{41} and κ_{42} are the coupling losses.

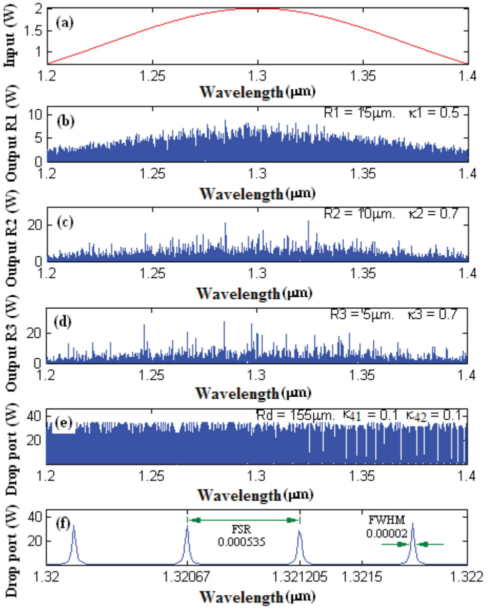

Figure 2. Result of the spatial pulses with center wavelength at 1.30 µm.

In operation, an optical field in the form of Gaussian pulse from a laser source at the specified center wavelength is input into the system. From Figure 2, the Gaussian pulse with center wavelength (λ_0) at 1.30 µm, pulse width (Full Width at Half Maximum, **FWHM**) of 20 ns, peak power at 2 W is input into the system as shown in Figure 2(a). The large bandwidth signals can be seen within the first, second microring and third nanoring device, and shown in Figure 2(b), 2(c) and 2(d), respectively. The suitable ring parameters are used, for instance, ring radii R_1= 15.0 µm, R_2 = 10.0 µm, R_3 = 5.0 µm, and R_d = 155.0 µm. In order to make the system associate with the practical device (Kokubun et al, 2005), the selected parameters of the system are fixed to n_0= 3.34 (**InGaAsP/InP**), A_{eff} = 0.50 µm^2, 0.10 µm^2 and 0.25 µm^2 for a microring, nanoring and add/drop ring resonator, respectively, α = 0.5 dBmm^{-1}, γ = 0.1. In this investigation, the coupling coefficient (kappa, κ) of the microring and nanoring resonators are ranged from 0.10 to 0.70. The nonlinear refractive index of the microring and nanoring used are n_2 = 2.2 x 10^{-17} m^2/W. Result of the spatial pulses with center wavelength at 1.30 µm, Figure 2(e), the large bandwidth signals, Fig. 2(f), the filtering and amplifying signals from the drop port. The maximum output power obtained is 40 W.

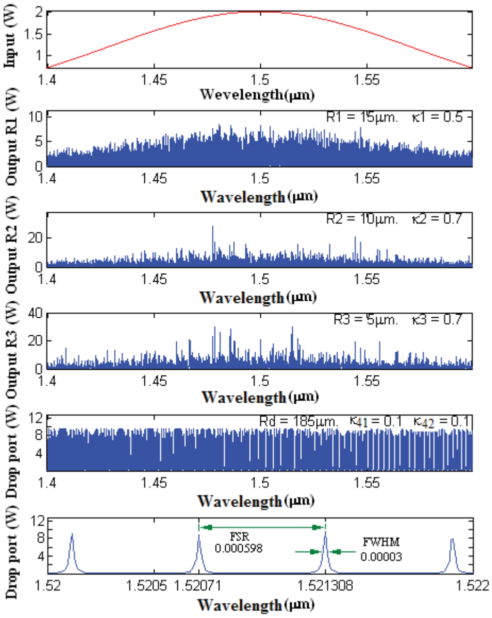

Figure 3. Result of the spatial pulses with center wavelength at 1.50 µm.

From Figure 3, the Gaussian pulse with center wavelength (λ_0) at 1.50 μm, pulse width of 20 ns, peak power at 2 W is input into the system as shown in Fig. 3(a). The large bandwidth signals can be seen within the first, second microring and third nanoring device, and shown in Figure 3(b), 3(c) and 3(d), respectively. The suitable ring parameters are used, for instance, ring radii R_1 = 15.0 µm, R_2 = 10.0 µm, R_3 = 5.0 µm, and R_d = 185.0 µm. Result of the spatial pulses with center wavelength at 1.50 µm, Figure 3(e), the large bandwidth signals, Figure 3(f), the filtering and amplifying signals from the drop port. The smallest free spectrum range (FSR) and spectral width ($\Delta\lambda$) of 598 and 30 pm are generated respectively. The maximum output power is 8 W which is available for high capacity and long distance communication link.

By using the propose design as shown in Figure 1, the extended light source wavelengths can be used for DWDM, which can be used with the existed public networks, the higher channel capacity can also be obtained by using FSR modification and more available wavelength bands, for instance, from near to far infrared wavelength bands. The smallest FSR obtained is about 500 pm as shown in Figures 2 and 3. The generated signals can be used as the modulated carrier that can be used to form the image transformation from the CCTV camera and computer server, while the synchronous link can be performed by the reference signal, therefore, the required image from the specific wavelength can be confirmed by the central controller. Furthermore, the non-dispersive wavelength (1.30 µm) can be extended and used to increase the communication capacity, moreover, the Gaussian pulse output power can be amplified, which can provide the power budget for long distance link. This can be used with the existed public network installation. Furthermore, the pumping part is not required in such a system. The new available wavelength bands can be use to form the new multi-layer protocol, where more communication capacity can be performed. In this case, the human privacy can be provided when the CCTV is operated. The required images can be viewed by the authorized person via the central controller (Computer server).

3. Conclusion

We have shown that the multi-wavelength bands can be generated by using a Gaussian pulse propagating within the microring resonator system, which is available for the extended DWDM with the wavelength center at 1, 300 and 1,500 nm, which can be used with the existed public networks. Moreover, the increasing in wavelength capacity can be used to increase the CCTV channels, while the human privacy can be kept by using the specific wavelength filter. Results obtained have shown that the spatial pulses width of 30 pm and the spectrum range of 600 pm can be generated and achieved. Moreover, the problem of signal collision can be solved by using the suitable FSR design (Yupapin et al, 2007), while the dispersion effect is minimized when the center wavelength at 1.30 μm.

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