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Decimal Convertor Application for Optical Wireless Communication by Generating of Dark and Bright Signals of soliton

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Abstract

Two systems consist of microring resonators (MRRs) and an add/drop filter are used to generate signals as localized multi wavelengths. Quantum dense encoding can be performed by output signals of selected wavelengths incorporated to a polarization control system. Therefore dark and bright optical soliton pulses with different time slot are generated. They can be converted into digital logic quantum codes using a decimal convertor system propagating along a wireless networks. Results show that multi soliton wavelength, ranged from 1.55μm to 1.56μm with FWHM and FSR of 10 pm and 600 pm can be generated respectively.
Keywords- Micro Ring Resonator, Quantum Dense Coding (QDC), Wireless network communication system

Introduction

Quantum network is highly recommended technology in order to perform the perfect network security. Afroozeh *et al* [1] have shown that micro ring resonators (MRR) can be used to generate multi wavelength. The entangled photon pair can be performed via the MRR system to generate secured key codes [2]. Dense wavelength of optical pulses is offered for quantum dense coding and quantum packet switching applications [3]. Up to now, a quantum method is much useful to provide high security in optical communication network [4]. Quantum key can be perform and generated using a nonlinear MRR system with appropriate parameters.

A new reliable system for wireless system is needed, which has both high capacity and secure tools. Quantum codes can be performed via optical tweezers signal, generated by a MRR system in a nonlinear medium with given input power and selected parameters [5, 6].

Amiri *et al* have proposed a technique, which can be used to communication security via the chaotic signals and up and down links of optical soliton pulses in which the use of quantum encoding of output signals is applicable [7]. Amiri *et al* have projected the use of secured codes applicable in quantum router and network system [8]. We have used a nonlinear MRR system to form the multi wavelength, applicable for quantum codes generation used in wireless network system.

Theoretical Modeling

Chaotic signals cancelation can be done using an optical add/drop filter system [9]. The schematic of the two proposed systems are shown in Fig.1.

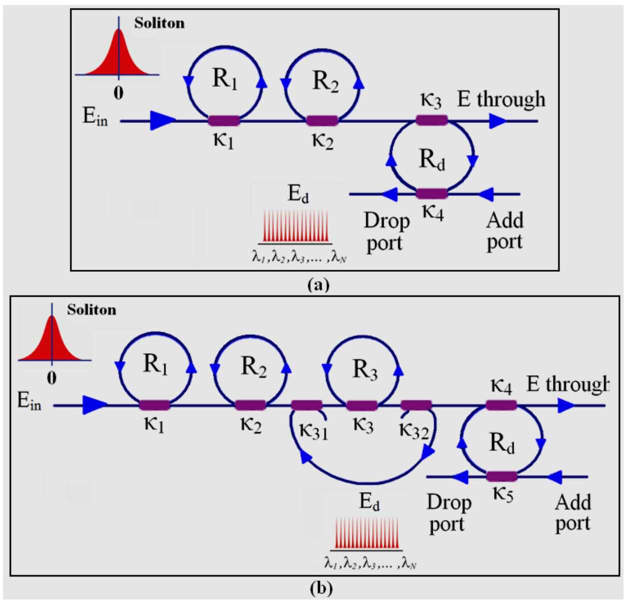

Fig.1. Systems of multi optical soliton pulse generation, (a): multi soliton generation, (b): multi soliton trapping and storage, R_s: ring radii, κ_s: coupling coefficients, κ_{31} and κ_{32} are coupling losses.

Bright soliton pulse is introduced into the proposed system. The input optical field (E_{in}) of the optical bright soliton can be expressed as [10],

$$E_{in} = A\,\mathrm{sech}\left[\frac{T}{T_0}\right]\exp\left[\left(\frac{z}{2L_D}\right) - i\omega_0 t\right] \tag{1}$$

A and z are the optical field amplitude and propagation distance, respectively. T is a soliton pulse propagation time in a frame moving at the group velocity, $T = t-\beta_1 * z$, where β_1 and β_2 are the coefficients of the linear and second order terms of Taylor expansion of the propagation constant. $L_D = T_0^2 / |\beta_2|$ is the dispersion length of the soliton pulse. The frequency shift of the soliton is ω_0. This solution describes a pulse that keeps its temporal width invariance as it propagates, and thus is called a temporal soliton. When a soliton peak intensity $(|\beta_2 / \Gamma T_0^2|)$ is given, then T_o is known. For the temporal optical soliton pulse in the micro ring device, a balance should be achieved between the dispersion length (L_D) and the nonlinear length ($L_{NL} = (1/\Gamma\phi_{NL})$, where $\Gamma = n_2 * k_0$, is the length scale over which dispersive or nonlinear effects makes the beam becomes wider or narrower, hence $L_D = L_{NL}$. When light propagates within the nonlinear medium, the refractive index (n) of light within the medium is given by [11]

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

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 MRR and NRR, the effective mode core areas range from 0.50 to 0.10 μm^2 [12]. The resonant output can be formed; therefore the normalized output signals of the light field which is the ratio between the output and input fields (E_{out} (t) and E_{in} (t)) in each roundtrip can be expressed by [13]

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

Equation (3) specifies that a ring resonator in the exacting case is very similar to a Fabry-Perot cavity, which has an input and output mirror with a field reflectivity, $(1-\kappa)$, and a fully reflecting mirror. κ is the coupling coefficient, and $x=\exp(-\alpha L/2)$ represents a roundtrip loss coefficient, $\Phi_0 = kLn_0$ and $\Phi_{NL} = kLn_2|E_{in}|^2$ are the linear and nonlinear phase shifts, $k=2\pi/\lambda$ is the wave propagation number in a vacuum. L and α are a waveguide length and linear absorption coefficient, respectively. In this investigation, 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 next ring resonators. The optical outputs of a ring resonator add/drop filter are given by Eq. (4) and Eq. (5) [14].

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

and

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

E_t and E_d represent the optical fields of the through port and drop ports, respectively. $\beta = kn_{eff}$ is the propagation constant, n_{eff} is the effective refractive index of the waveguide, and the circumference of the ring is $L=2\pi R$, with R as the radius of the ring [15]. New parameters are introduced for simplification with $\phi = \beta L$ as the phase constant. By using the specific parameters of the add/drop device, the chaotic noise cancellation can be obtained and the required signals can be retrieved by the specific users. κ_1 and κ_2 are the coupling coefficients of the add/drop filters, $k_n=2\pi/\lambda$ is the wave propagation number in a vacuum, and the waveguide (ring resonator) loss is α = 0.5 $dBmm^{-1}$ [16]. The fractional coupler intensity loss is γ = 0.1. In the case of the add/drop device, the nonlinear refractive index is neglected [17]. High capacity of optical pulses can be obtained when the full width at half maximum (FWHM) of these pulses are very small, where the amplification is performed inside the micro or nanoring system [18, 19].

Results and Discussion:

From Fig. 1(a) the input soliton pulse has 20 ns pulse width, peak power of 500 mW. The ring radii are R_1= 10 μm, R_2= 5 μm, and R_d = 200 μm. the fixed parameter are selected to λ_0 = 1.55 μm, n_0 = 3.34 (InGaAsP/InP), A_{eff} = 0.25 μm^2, α = 0.5 $dBmm^{-1}$, γ = 0.1. The coupling coefficients range from 0.50 to 0.975, where the nonlinear refractive index is n_2 = 2.2 x 10^{-17} m^2/W and the wave guided loss used is 0.5$dBmm^{-1}$. Optical signals are sliced into smaller signals broadening over the band as shown in Fig. 2(b). Therefore, large bandwidth signal is formed within the first ring device, where compress bandwidth with smaller group velocity is attained inside the ring R_2, such as filtering signals. Localized soliton pulses are formed, when resonant condition is performed, given in Fig. 2(d). However, there are two types of temporal and spatial soliton pulses. Here the multi soliton pulses with FSR and FHWM of 600 pm, and FWHM of 10 pm.

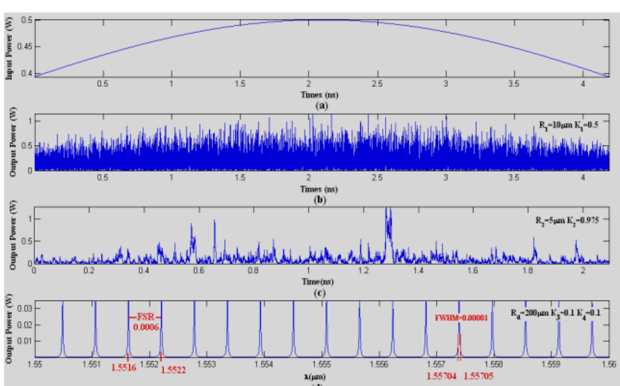

Fig. 2: Results of the multi-soliton pulse generation, (a): input soliton, (b): large bandwidth signals, (c): temporal soliton, (d): spatial soliton with FSR of 600 pm, and FWHM of 10 pm.

Fig (3) show the generation of optical multi soliton signals, where Fig. 1(c) shows the trapping of optical soliton within the MRRs system with ring radii of R_1= 10 μm, R_2=R_3= 4 μm, and R_d= 200 μm. Therefore, by using suitable ring resonator parameters, localized wavelength can be obtained. From Figure (3), (a) large bandwidth signals, (b) and (c) trapping of temporal soliton pulses, (d) localized spatial multi solitons. Amplification of optical soliton is perform used to long transmission link. The power distribution of the output pulses can be executed via the add/drop filter with radius of R_d as shown in Fig. 3(d).

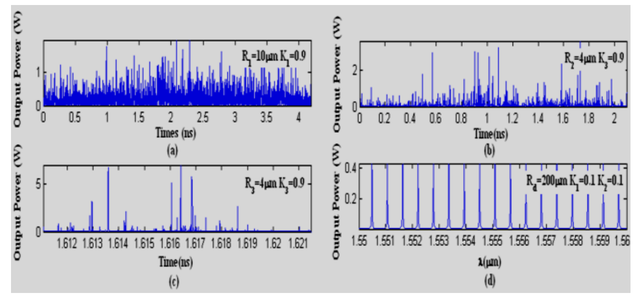

Fig. 3: Results of the multi-soliton pulse generation where (a): the large bandwidth signals, (b) and (c): temporal solitons, (d) the localized spatial solitons

Generated multi soliton pulses can be transmitted into the wireless network systems. Increasing in communication capacity is provided by increasing of soliton pulses (λ_i), which can be performed by generation of temporal and spatial optical soliton pulses. Therefore, the high capacity and secured signals can be transmitted and retrieved via quantum codes. Here the quantum codes can be generated by generation of dark and bright optical solitons when the optical multi soliton pulses pass through the polarization control unit shown in Fig. 4.

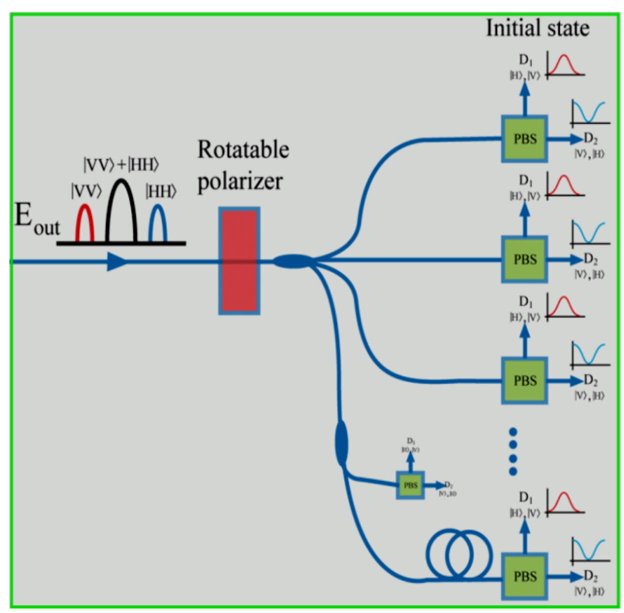

Fig.4. System of dark and bright generation applicable for coding process, where PBS is a beam splitter and Ds are the detectors.

Generated dark and bright soliton pulses can be converted to digital codes of “0” and “1” by using analog to digital electronic convertor system. This system is known as optical binary to decimal convertor system which is applicable to generate digital codes. The proposed optical binary to decimal convertor system is show in Fig. 5. The input and control light pulse trains are input into the first add/drop optical filter (MRR1) using dark soliton (logic ‘0’) or the bright soliton (logic ‘1’). First, the dark soliton is converted to be dark and bright soliton via the add/drop optical filter, which they can be seen at the through and drop ports with π phase shift. By using the add/drop optical filter (MRR2 and MRR3), both input signals are generated by the first stage add/drop optical filter. Next, the input data, ”Y” with logic “0” (dark soliton) and logic “1” (bright soliton) are added into the both add ports, where the dark-bright soliton conversion with π phase shift is operated again. For large scale, results obtained are simultaneously seen by T2, D2, T3 and D3 at the drop and through ports for optical logic operation.

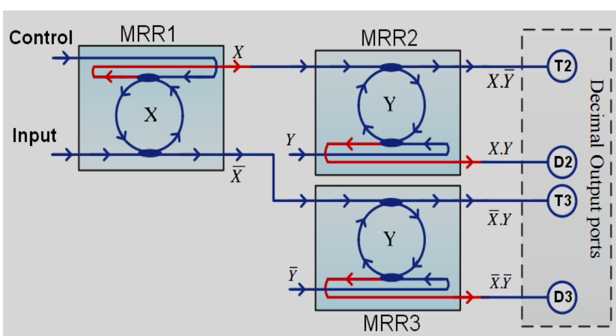

Fig.5. System of binary to decimal convertor, where T and D are the through and drop ports of the system

From Fig. 5, the optical pulse train X,Y is fed into MRR2 from input and add ports, respectively, in which the optical pulse trains that appear at the through and drop ports of MRR2 will be $X\,\overline{Y}$ and $X\,Y$ respectively. When the optical pulse train $\overline{X}\,,\overline{Y}$ is fed into MRR3 from input and add ports, respectively, the optical pulse trains that appear at the through and drop ports of MRR3 will be $\overline{X}\,Y$ and $\overline{X}\,\overline{Y}$, respectively. Therefore, generation of logic codes of “0” and “1”, can be easily done by using series of beam splitters (B.S) connected to the binary to decimal convertor system. In simulation, the add/drop optical filter parameters are fixed for all coupling coefficients to be, $\kappa_s = 0.05$, $R_{ad} = 300\,nm$, $A_{eff} = 0.25\mu m^2$, $\alpha = 0.05\,dBmm^{-1}$. Here, the results show the generation of optical logic codes of “00”, “01”, “10” and “11”, using the MRRs proposed system. A wireless router system can be used to decode the logic codes, transfer them via a wireless access point, and network communication system shown in Fig. 6.

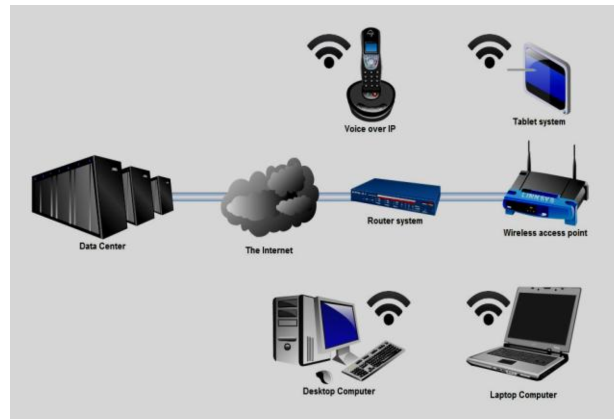

Fig.6: System of dark and bright generation applicable for coding process, where PBS is a Polarizing beam splitter and Ds are the detectors.

A wireless access system transmits data to different users via wireless connection.

Conclusion

Interesting concept of digital codes generation was presented. Optical communication capacity can be increased by the multi soliton pulses generation, where more soliton channels can be generated by using the MRR system. The required channels are obtained by filtering the large bandwidth signals using an add/drop filter system. Digital codes of “0” and “1” can be generated within the optical binary to decimal convertor system. The advantage of the system is that the clear signal can be retrieved by the specific add/drop filter. Generated digital codes can be transmitted into network communication systems via a wireless system.

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Reference

[1]. Abdolkarim Afroozeh, Iraj Sadegh Amiri, Muhammad Arif Jalil, Mojgan Kouhnavard, Jalil Ali, Preecha Yupapin. Multi Soliton Generation for Enhance Optical Communication, Applied Mechanics and Materials, Vol. 83 (2011), pp 136-140

[2]. I. S. Amiri, A. Afroozeh, M. Bahadoran, J. Ali & P. P. Yupapin. Molecular Transporter System for Qubits Generation, Jurnal Teknologi, 55 (2011), 155–165.

[3]. P.P. Yupapin, M. A. Jalil, I. S. Amiri, I. Naim, J. Ali. New Communication Bands Generated by using a Soliton Pulse within a Resonator System, Circuits and Systems, 2010, 1, 71-75

[4]. M. Kouhnavard, I. S. Amiri, A. Afroozeh, M. A. Jalil, J. Ali and P. P Yupapin. QKD Via a Quantum Wavelength Router using Spatial Soliton, AIP Conf. Proc. 1341, 210-216 (2011)

[5] I. S. Amiri, A. Nikoukar, J. Ali. Quantum Information Generation Using Optical Potential Well, 2nd Annual International Conference on Network Technologies & Communications (NTC 2011), publishing progress.

[6] A. Nikoukar, I. S. Amiri, J. Ali. Secured Binary Codes Generation for Computer Network Communication, 2nd Annual International Conference on Network Technologies & Communications (NTC 2011), publishing progress.

[7]. I. S. Amiri, A. Afroozeh, J. Ali And P. P. Yupapin. Generation of Quantum Codes Using Up and Down Link Optical Soliton, Jurnal Teknologi, 55 (2011), 97–106.

[8] I. S. Amiri, M.H. Khanmirzaei, M. Kouhnavard, P.P. Yupapin, J. Ali. Quantum Entanglement using Multi Dark Soliton Correlation for Multivariable Quantum Router. Nova Science Publisher, 2011.

[9]. Muhammad Arif Jalil, Iraj Sadegh Amiri, Chat Teeka, Jalil Ali, P. P. Yupapin. All-optical Logic XOR/XNOR Gate Operation using Microring and Nanoring Resonators, Global Journal of Physics Express, Volume 1, Issue 1, 2011, 15-22.

[10]. A. Afroozeh, I. S. Amiri, M. Kouhnavard, M. A. Jalil, J. Ali, and P.P. Yupapin. Optical Dark and Bright Soliton Generation and Amplification, AIP Conf. Proc. 1341, 259-263 (2011)

[11]. N. Suwanpayak, S. Songmuang, M. A. Jalil, I. S. Amiri, I. Naim, J. Ali and P. P. Yupapin. Tunable and Storage Potential Well Using Microring Resonator System for Bio-Cell Trapping and Delivery, AIP Conf. Proc. 1341, 289-291 (2011)

[12]. C. Teeka, S. Songmuang, R. Jomtarak, P. P. Yupapin, M. A. Jalil, I. S. Amiri, and J. Ali. ASK-to-PSK Generation based on Nonlinear Microring Resonators Coupled to One MZI Arm, AIP Conf. Proc. 1341, 221-223 (2011)

[13]. I. S. Amiri, K. Raman, A. Afroozeh, M.A. Jalil, I.N. Nawi, J. Ali, P.P. Yupapin. Generation of DSA for Security Application, (2011) Procedia Engineering, 8, pp. 360-365.

[14]. I. S. Amiri, J. Ali, P.P. Yupapin. Enhancement of FSR and Finesse Using Add/Drop Filter and PANDA Ring Resonator Systems, International Journal of Modern Physics B, Vol. 25, No. 00 (2011) 1–13

[15]. I. S. Amiri, A. Afroozeh, I.N. Nawi, M.A. Jalil, A. Mohamad, J. Ali, P.P. Yupapin. Dark Soliton Array for communication security, (2011) Procedia Engineering, 8, pp. 417-422.

[16]. C. Tanaram , C. Teeka, R. Jomtarak, P. P. Yupapin, M. A. Jalil, I. S. Amiri and J. Ali. ASK-to-PSK Generation based on Nonlinear Microring Resonators Coupled to One MZI Arm, (2011) Procedia Engineering, 8, pp. 432-435.

[17]. I. S. Amiri, A. Afroozeh, M. Bahadoran. Simulation and Analysis of Multi Soliton Generation Using a PANDA Ring Resonator System, CHIN.PHYS. LETT. Vol. 28, No. 10 (2011) 104205,

[18]. A. Afroozeh, I. S. Amiri, J. Ali And P. P. Yupapin. Determination of FWHM for Soliton Trapping, Jurnal Teknologi, 55 (2011), 77–83.

[19]. A. Afroozeh, I. S. Amiri, M. Bahadoran, J. Ali & P. P. Yupapin. Simulation of Soliton Amplification in Micro Ring Resonator for Optical Communication, Jurnal Teknologi, 55 (2011), 271–277.