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A novel optical radio on fiber multi-channel by micro ring resonator system

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Abstract

We propose a novel system that can be used to generate the new optical radio on fiber communication continuous variable channel using a Gaussian pulse propagating within a nonlinear micro-nanoring resonator system. By using the wide range of the Gaussian input for instance, when the input pulses of the common lasers with centre wavelengths from 1,300 nm are used, which this system is simple for used. Results obtained have shown that more available wavelength bands and frequency domain(THz) from the different ring parameter and wavelengths can be generated, which can be used to form new optical to high frequency ranges, whereas the use of the very high channel capacity for personal wavelength and very high security and multi-channel in network applications is plausible.

Keywords: high frequency; wireless security; RoF and multi channel

1. Introduction

The Radio on fiber of THz frequency has been recognized as the challenging device for various application to distributed target tracking using signal strength measurements by a wireless sensor network, a single-chip CMOS UHF RFID reader transceiver for Chinese mobile applications, wafer-level

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Parylene packaging with integrated RF electronics for wireless retinal prostheses and hybrid RFID employing optical wireless communication and radio on fiber on THz communication broadband antenna-integrated, edge-coupled mixers for tuneable Terahertz Sources [1-6]. Furthermore, the Gaussian pulse generator is a simple, easily and compact design, making it more commercially viable.

In this paper, we present the theoretical background in the physical model concept, where design can be use to the novel nano radio system design for radio on fiber application. In application, the high capacity channel, this is available for high security and high capacity via optical RoF application and wireless radio link system.

2. THz Frequency Band Generation

Light from a monochromatic light source is launched into a ring resonator with constant light field amplitude (E_0) and the router quantum key distribution 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 [14]

$$E_{in}(t) = E_0 e^{-\alpha L + j\phi_0(t)}. \tag{1}$$

Here 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

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

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.

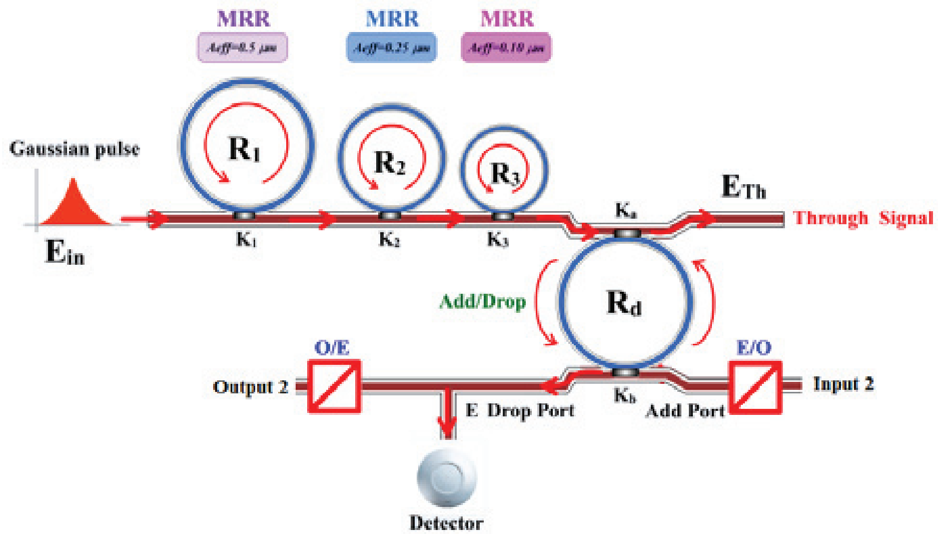

Fig. 1. Schematic of Optical THz frequency carrier system, where Rs: Ring radii, Ks: Coupling coefficients, K_a and K_b are add/drop multiplexing coupling coefficients, the system dimension is 100 x 50 μm^2

In Fig. 1 show optical RFID system to access point broadband antenna-integrated edge-coupled photo mixers for tunable terahertz sources [6] and antenna-integrated photodiodes with strained absorbers designed for use as terahertz sources [7] and the transmitter / receiver access point have synchronization system. The signal send throughout by the antenna T_x and the receiver when receive the signal coming into the system again.

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 [8-9].

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

Equation (3) 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

$\phi_x = \exp(-\alpha L/2)$ 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 (4), 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 (2). 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).

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

and

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

Here 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 [10].

Here $\beta = kn_{eff}$ 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 is linear device.

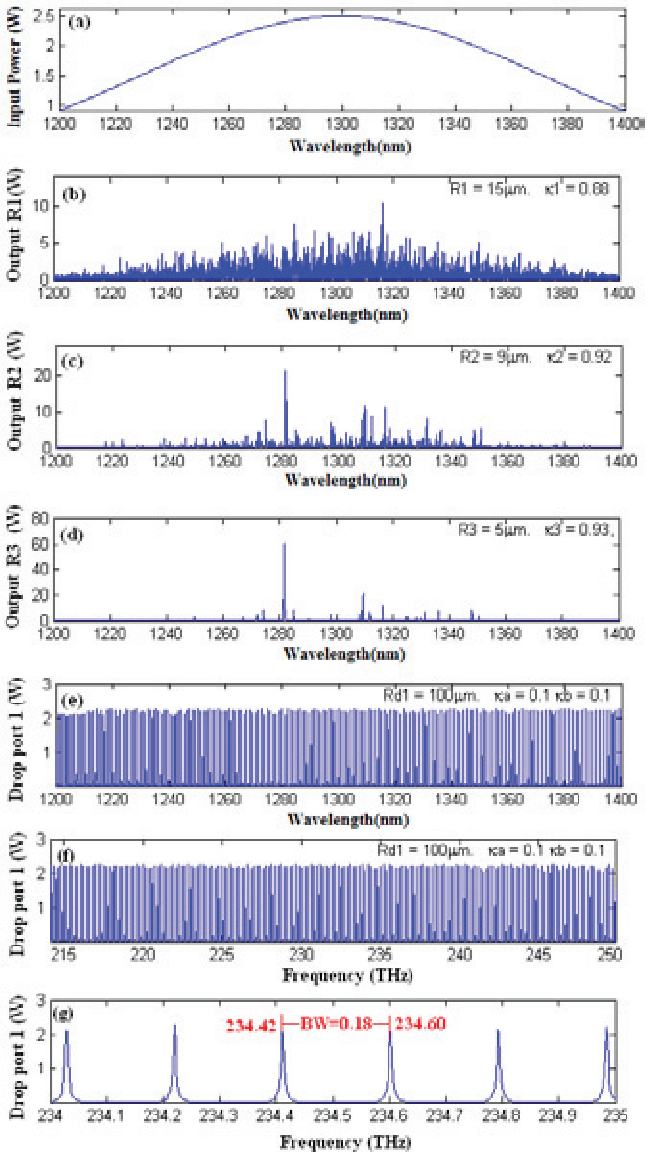

Fig. 2. Show the signal of THz frequency carrier by nano ring resonator

In Fig. 2 show the result of the rings and add/drop device which input signal is Gaussian pulse 2.5 W in Fig. 2(a). The output of first ring (R_1) is chaotic signal and cancellation chaotic signal by the second (R_2) and the third ring (R_3). The parameters of ring radii are 15µm, 9 µm and 5 µm for R_1-R_3 show Fig.2 (b-d) and the couple coefficient of the rings are 0.88, 0.92 and 0.93. The center wavelength is 1.3 µm in Fig.2 (e) and Fig.2 (f) show the output signals of drop port and through put port by ring radii of add/drop is 100µm. The Fig. 2(f) and Fig. 2(g) show the exchange spatial mode to frequency domain of through put port and drop port at the frequency between 234.42-2341.60 THz and bandwidth (BW) is 0.18 THz.

3. Radio Frequency Band Generation

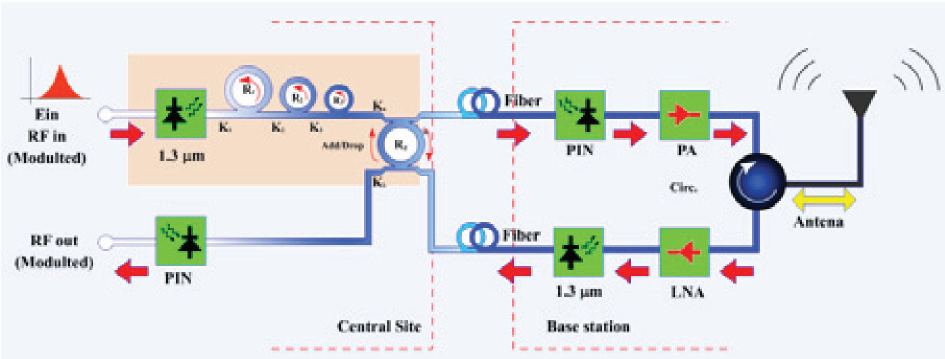

Fig. 3. Shows the 200 THz fiber-radio systems

While Fig. 3 shows the transmission of the RF signal at its frequency, it is not always necessary to do that. For instance, a Local Oscillator (LO) signal, if available, may be used to down-convert the uplink carrier to an intermediate frequency (IF) by the optical THz signal in the central site. Instead of placing a separate LO in the optical ring resonator system, it may be transported from the central site to the antenna by the RoF system.

This results in a much simpler antenna unit. In this configuration, the downlink becomes the crucial part of the RoF since it has to transport high-frequency signals. The transportation of high-frequency (THz) signals is more challenging because it requires high frequency components, and large link bandwidth. This means that high-frequency signals are more susceptible to transmitter, receiver, and transmission link signal impairments.

4. Radio on fiber application

The radio on fiber (ROF) technology entails the use of optical fiber links to distribute RF signals from a central location to THz antenna units. In narrowband communication systems and WLANs, the RF signal processing functions such as frequency up-conversion, carrier modulation THz communication and multiplexing, are performed at the base station and immediately fed into the antenna. ROF makes it possible to centralize the RF signal processing functions in one shared location and then to use optical fiber, which offers low signal loss (0.5 dB/km for 1.31 µm wavelengths). The centralization of RF signal processing functions enables equipment sharing, dynamic allocation of resources, and simplified system operation and maintenance.

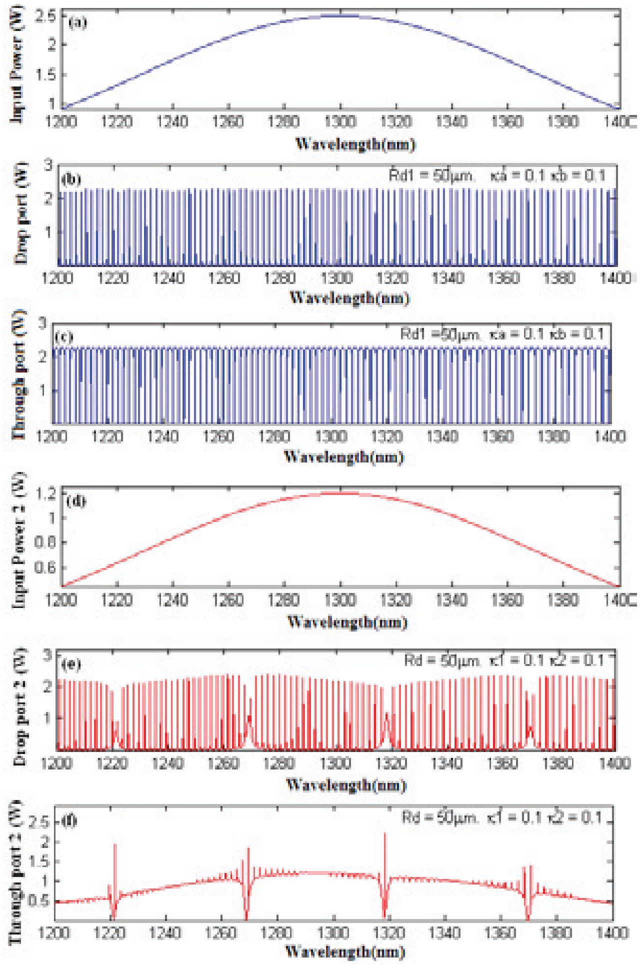

Fig. 4. Show the optimum result of radio on fiber system

In Fig. 4 show the signal input Gaussian pulse in Fig. 4(a). The output drop port and through port show in Fig. 4(b-c) and input power Add port show in Fig. 4(d), which output radio signal feedback signal on drop port 2 and through port 2 show in Fig. 4(e-f) show the many channel from Fig. 3, which can design the multi-channel by varies the radius of add/drop multiplexing.

This system of the pioneer RoF system implementations is depicted in Fig. 4. Such a system may be used to distribute GSM signals and THz communication for example. The RF signal is used to directly modulate the laser diode and optical THz generation in the central site. The resulting intensity modulated optical signal is then transported over the length of the fiber optic to the base station. At the base station on the transmitted RF signal is recovered by direct detection in the PIN photo detector. The signal is then amplified and radiated by the antenna THz [11-12]. The uplink signal from the base station is transported from the RAU to the central site in the same way. This method of transporting RF signals over the fiber is called intensity modulation with direct detection (IM-DD) [13] and is the simplest form of the RoF up link and down link.

- *Low loss*

The optical fiber offers very low loss, ROF technology can be used to achieve both low-loss distribution of mm-waves, and simplification of THz antenna at the same time. Commercially available standard Single Mode Fibers (SMFs) made from glass (silica) have attenuation losses below 0.2 dB/km and 0.5 dB/km in the 1550 nm and the 1300 nm windows.

- *Large Bandwidth*

Optical fibers offer enormous bandwidth. There are three main transmission windows, which offer low attenuation, namely the 850 nm, 1310 nm, and 1550 nm wavelengths. The RoF advanced multiplex techniques namely Optical Time Division Multiplexing (OTDM) in combination with Dense Wavelength Division Multiplex (DWDM) techniques.

- *Immunity to Radio Frequency Interference*

Immunity to Electro Magnetic Interference (EMI) is a very attractive property of optical fiber communications, especially for microwave transmission. This is so because signals are transmitted in the form of light through the fiber. Because of this immunity, fiber cables are preferred even for short connections at mm-waves. Related to EMI immunity is the immunity to eavesdropping, which is an important characteristic of optical fiber communications, as it provides privacy and security.

5. Conclusion

We present carrier generation THz frequency for radio on fiber in optical waveguide and very simple connection and technique on continues variable high frequency (THz) for multi-channel. An add/drop filters that are in the parts can be used to form transmitter (T_X) and receiver (R_X) states in the link and wireless communication for THz frequency, respectively. Results obtained have shown that the multiplexed signals can be performed by using the wavelength router and change to frequency domain in the single and similar system, which is allowed to retrieve the radio on fiber application multi-channel by the end users.

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