40Gb/s optical 3R-regeneration Based on XPM in PCF

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***Abstract*-We demonstrate 3R-regeneration method based on XPM in PCF. The most important part of this system is a MZI Optical Switch which have one high-Nonlinear PCF arm. By adjusting the length of the PCF, we can make the centre of the optical pulse obtain a phase shift about π, this optical pulse transmitted through the PCF interfere with the optical pulse transmitted through the other arm, the degraded data signal get regeneration . The experiment is simulated with Optisystem.**

Keywords-3R-regeneration, PCF, XPM

I. INTRODUCTION

In light communications network in the, fibre and various light devices of loss will caused signal of attenuation; dispersion (Group speed dispersion and polarization die dispersion), will led light signal of broadening and malformation, occurs code between interference, makes system of BER increased, limit has network node level joint of ability, serious effect communications quality, eventually limit has system and network of transmission rate and distance [1]. So full off 3R regeneration repeatedly to Re-amplifying, Re-timing, Re-shaping became essential [2,3].

Re-shaping is an important part in all-optical 3R regeneration, it determines the final output of signal regeneration performance. Re-shaping optical signal using optical switch to judgement and core technology is shaping the design of the optical switch. Currently implemented in all-optical 3R-optical method of the judgement are: based on semiconductor saturable absorption effect of electro-absorption modulator (EAM), based on Nonlinear Optical loop mirror (NOLM), Mach based on XPM effects of SOA have de Interferometer (SOA-MZI) or Michelson Interferometer (SOA-MI). Which based on EAM of light switch system using EAM of nonlinear cross saturated absorption effect, performance stability, but EAM work Shi need DC partial reset voltage, so is does not Shang full significance Shang of full light judgment; based on Nonlinear optical ring mirror (NOLM) of light open work rate high, but exists size large, and difficult integrated; based on SOA of Mach a has de interference instrument (SOA-MZI) light switch system because semiconductor carrier slow recovery time characteristics limit has switch work speed, effect its level joint ability.

This article by using Photonic Crystal fiber nonlinear effects [4], constructed based on Photonic Crystal fiber XPM effects of all-optical switch, realizing all-optical 3R regeneration, simple structure, low cost, stable performance.

II. THEORETICAL ANALYSIS

When there is a strong power in optical fiber magnetic field, the electrodes caused by external electric field strength and applied electric field strength e p's of nonlinear relations can be expressed as

$$P = \varepsilon_0 (x E^{(1)} + x^{(2)} EE + x^{(3)} EEE + \ldots.) \quad (1)$$

In the formula: ε0 is the permittivity of vacuum, $x^{(j)}$ is j-order susceptibility tensor. In the quartz glass, because the media is inversion symmetry, $x^{(2)}$ disappeared, $x^{(3)}$ has become the most important non-linear components. In monochrome approximate cases, to separate fast changing parts of the electric field, write the following form:

$$E(r,t) = \frac{1}{2}\hat{x}(E_1 e^{-i\omega_1 t} + E_2 e^{-i\omega_2 t}) + c \bullet c \quad (2)$$

Crystals of nonlinear polarization can be expressed as:

$$P_{NL}(r,t) = \varepsilon_0 \chi^{(3)} : E(r,t)E(r,t)E(r,t) \quad (3)$$

(2), substitute (3):

$$P_{NL}(r,t) = \frac{1}{2}\hat{x}\left\{\begin{array}{l} P_{NL}(\omega_1)\exp(-i\omega_1 t) + P_{NL}(\omega_2)\exp(-i\omega_2 t) + \\ P_{NL}(2\omega_1-\omega_2)\exp[-i(2\omega_1-\omega_2)t] + \\ P_{NL}(2\omega_2-\omega_1)\exp[-i(2\omega_2-\omega_1)t] \end{array}\right\} + c \bullet c \quad (4)$$

$$P_{NL}(\omega_1) = \chi_{eff}(|E_1|^2 + 2|E_2|^2)E_1;$$

$$P_{NL}(\omega_2) = \chi_{eff}(|E_2|^2 + 2|E_1|^2)E_2$$

$$P_{NL}(2\omega_1-\omega_2) = \chi_{eff}(E_1^2 E_2^*);$$

$$P_{NL}(2\omega_2-\omega_1) = \chi_{eff}(E_2^2 E_1^*) \cdot \quad (5)$$

$\chi_{eff} = \frac{3\varepsilon_0}{4}\chi^{(3)}_{XXXX}$ Used as an effective nonlinear parameters.

(4) produced a new frequency $2\omega_1-\omega_2; 2\omega_2-\omega_1;$ areas belonging to the four-wave mixing discussions, certain conditions must be met in order to produce, and the actual process in General does not meet, so ignore the two. The remaining two have a nonlinear effect on refractive index. You can see:

$$P_{NL}(\omega_j) = \varepsilon_0 \varepsilon_j^{NL} E_j \quad (j=1,2) \quad (6)$$

Associate it with a linear part together:

$$P(\omega_j) = \varepsilon_0 \varepsilon_j E_j \quad (7)$$

Where:

$$\varepsilon_j = \varepsilon_j^{NL} + \varepsilon_j^{L} = (n_j^{L} + \Delta n_j)^2 \quad (8)$$

n_j^L Is the linear part of the refractive index, Δn_j is caused between three nonlinear effect of refractive, index change. Use $\Delta n_j \ll n_j^L (j = 1, 2)$ the nonlinear part is

$$\Delta n_j \approx \varepsilon_j^{NL} / 2 n_j \approx n_2 (|E_j|^2 + 2|E_{3-j}|^2) \quad (9)$$

By (9), optical refractive index and its strength not only relevant, but also with other waves related to the strength of common transport. When you are in optical fiber transmission, will get a strength-related nonlinear phase:

$$\phi_j^{NL}(z) = \frac{\omega_j z}{c} \Delta n_j = \frac{\omega_j z n_2}{c} (|E_j|^2 + 2|E_{3-j}|^2) \quad (10)$$

Type on, corresponding to the first House is divided against itself to modulation of SPM, corresponding to the second is the cross-phase modulation XPM.

Then $E_{3-j} \gg E_j$ is divided against itself to modulation can be ignored, (2-10) can be simplified to:

$$\phi^{NL} = 2\gamma P_P L \quad (11)$$

Where $\gamma = \frac{\omega_j n_2}{c}$ is the nonlinear coefficient of the medium, and $P_P = |E_{3-j}|^2$, L=Z for the interaction length.

III. PROGRAMME DESIGN

Using cross-phase modulation to make this programme a three port optical switch, optical signal with the light switch and then Re-shaping. (1) is a three-port based on the Mach-Zehnder Interferometer optical switching, is also a central part of the programme. Pump light (clock pulse) as a switching signal, after amplification and signal photo merging into the PCF nonlinear effects all the way. As the signal power is far less than the pump power, so self phase modulation effects can be ignored. By (2-11) volume of cross-phase modulation signal light phase-shifting $\Phi_{NL} = 2\gamma P_P L$ that occurs. Adjust the values of L has both beam linear phase difference is an π odd number of times; at the same time through the nonlinear phase shift of the XPM effect in Photonic crystal fibers in clock pulse peak power for π; two-channel optical signal after interference. As figure (2) by as shown in because in clock pulse peak Department, upper and lower signal light code Yuan Center has 2π integer times of phase difference, therefore occurs phase long interference and improve, and corresponds clock pulse power for 0 of part because upper and lower two road signal light of phase difference for of π odd number times, produced phase Xiao interference and reduce, suppression has noise; to implementation signal Re-shaping and purification of purpose. Reason for using Photonic Crystal fiber in the experiment are: General silica fiber γ value is small (2.7W-1Km-1), and now know of ultra high nonlinearity Photonic Crystal fiber nonlinear coefficient ≥ 300 W-1km-1[9 at 1550nm wavelengths] shorter lengths can be used to achieve a sufficient number of non-linear effect, greatly improving the degree of system integration.

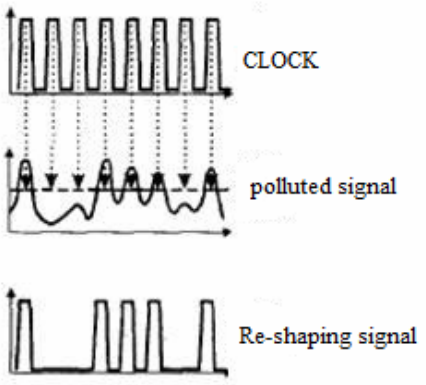

Figure 2. Reshaping process.

Overall structure of the system in figure (2), as shown in the pseudo random sequence generator driven with 40G/s Gaussian optical pulse generator, producing load wave length 1548nm optical signals, signal power of 1mW. Dispersion and attenuation, noise occurs in the transfer process. Receiving first attenuation of signals through the EDFA optical zoom (Re-amplifying). After amplification of signal into two roads, all the way into the clock clock recovery module, extraction of clock signal wavelength 1551nm, power 100mW. Together with the other all the way into the three port optical switching, signal light to broadening and noise pollution are Re-shaping (Re-shaping).

IV. SIMULATION RESULTS

Figure (4) and (5) the contrast can be seen in transit due to the loss of optical fiber and optical device can cause signal attenuation; dispersion will lead to broadening and deformity and mixed with the noise of the light signal. (6) degraded signal serious damage, eye stitch blur, noise margins is extremely low.

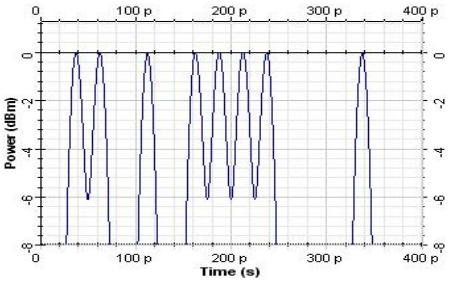

Figure 4. initial signal

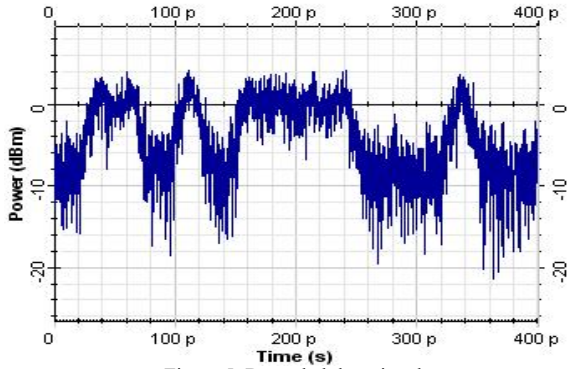

Figure 5. Degraded data signal

Figure (7) and (6) the contrast can be seen, after going through this system, eye diagram of the signal has been much improved, stitch clearer, noise margins improving, description of this system to effectively improve the impaired signal quality, through the Xpm effect suppresses noise, clean signal, enabling 3R regeneration effect.

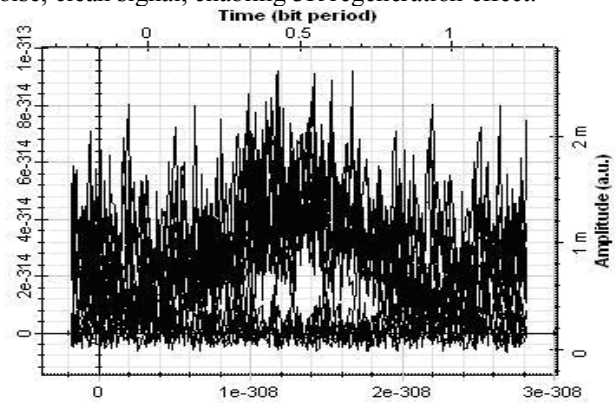

Figure 6. Eye diagram of degraded data signal.

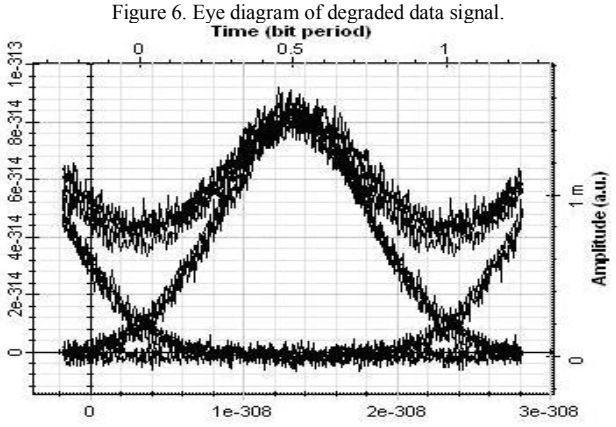

Figure 7 . Eye diagram of the regenerated signal.

V. CONCLUSION

This article studies the use of highly nonlinear Photonic Crystal fiber cross-phase modulation of 3R signal regeneration method. Method is simple, reliable performance, make the regeneration of signal quality improved significantly. [7] the use of four-wave mixing in methods are as follows:

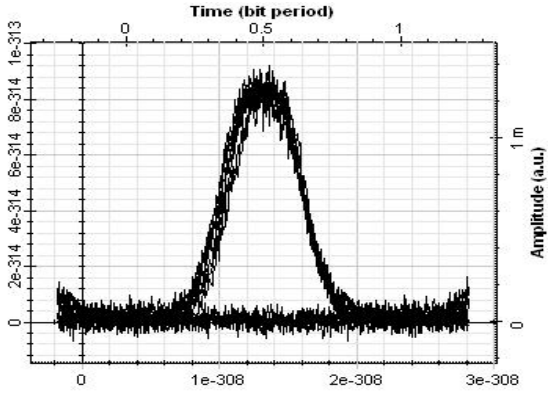

Figure 9. Eye diagram of the regenerated signal in Reference[9].

Comparison with this system: two eye-diagram of the system regenerates the signal noise margins the same (all 7.5E-314); however this system more simple and compact design, two roots are used in Photonic Crystal fiber and wavelength conversion using. This system is only a signal using a Photonic Crystal fiber and Re-shaping, reduce the complexity of the design and manufacturing, production cost savings, and reduced the volume increased system integration.

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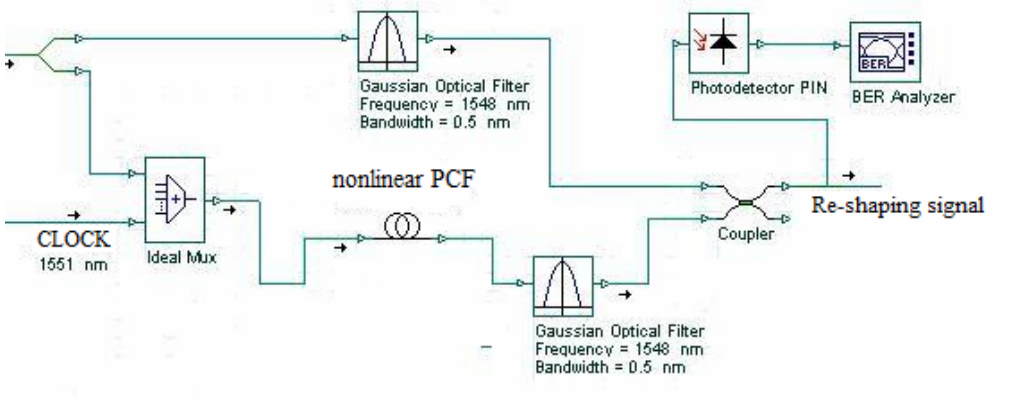

Figure 1. The 3ports optical switch for reshaping.

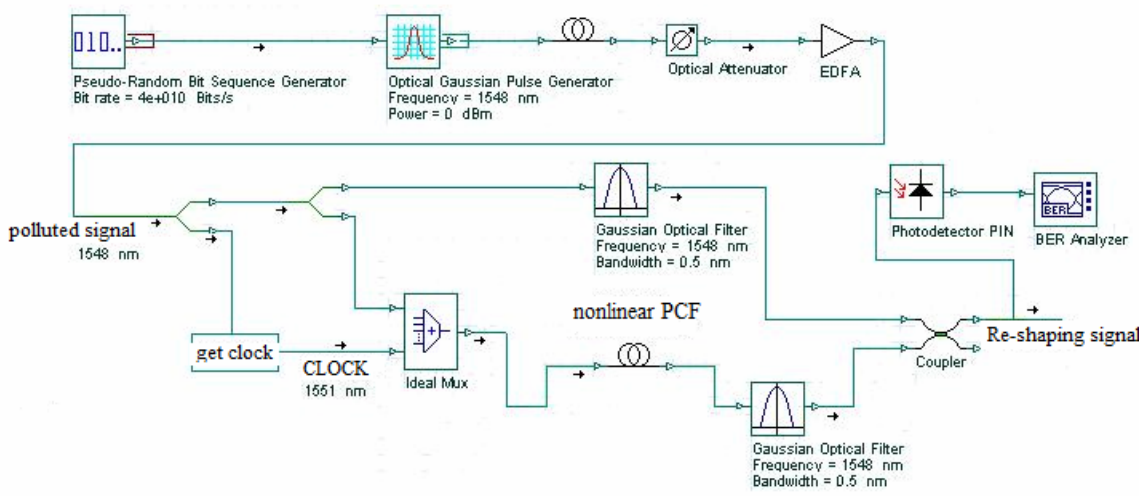

Figure 3. Schematic diagram of our proposed all-optical 3R regeneration

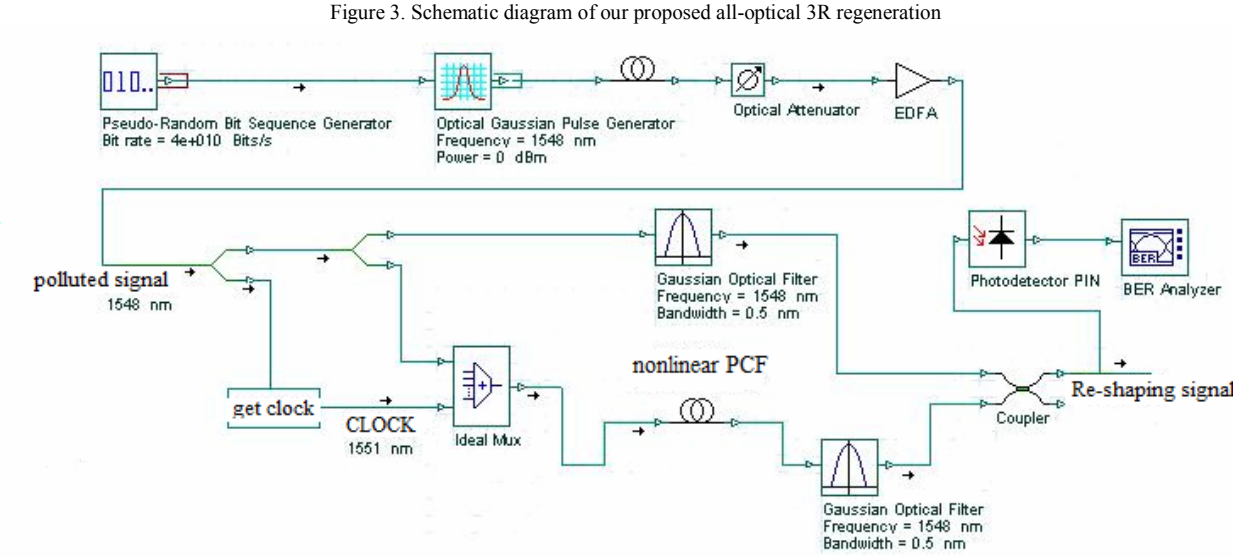

Figure 8. Schematic diagram of Reference