Short Communication

Analysis of Soliton Interaction in Optical Fiber Communication

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Abstract. If we transmit more than a single pulse at a time inside the optical fiber then we have to maintain the minimum separation (6 ps) between the consecutive pulses. Interactions of solitons are studied using the modified nonlinear Schrödinger equation, which models nonlinear optical pulses in a single mode fiber. The main objective of this paper is to show the minimum separation of 6ps must require between two soliton pulses to increase the information carrying capacity of the fiber.

Key words: Normalized time; relative separation; relative amplitude.

1. INTRODUCTION

With the advance of the information technology and explosive growth of the graphics driven World Wide Web, the demand for high bit rate communication systems have been rising exponentially, hence optical fiber has become the essential way for communication. When the information carrying light pulse transmits through an optical fiber, they suffer from attenuation; temporal broadening and they have interacted with each other through nonlinear effect in the fiber. These effects tend to distort the signals resulting in the loss of information. Solitons are able to propagate for long distance in optical fiber, because it can maintain its shapes when propagating through the fibers. Solitons are a special type of optical pulses that can propagate through an optical fiber without dispersion and loss of tens of thousands of km.

1.1. SOLITON INTERACTION

Solitonic pulses are transmitted through the communication channel without separation then these pulses get changes in shape and produce losses. Asolitonic pulse can be assumed to be as a charged particle, so it either repel or attract to the other pulses depending upon the charges or we can say the phases. Interaction between solitons is one of the major factors that limit the transmission.

The equation of propagation when two soliton pulses are propagating in the optical fiber together is given by equation (1) (Govind, 1997; Agrawal, 2006).

\[ u(\xi, \tau) = [\sec h(\xi - q_0)] + r \sec h(r + q_0)] \exp(i\phi) \] (1)

Here \( r \) is the normalized time, \( r \) is the relative amplitude, \( q_0 \) is the separation between the pulses, \( \phi \) is the relative phase between the pulses.

The plotting for the interaction between the two pulses by varying the relative separation, let consider the other parameter pulse width \( T_0 = 10 \text{ps} \); dispersion length \( L_d = T_0/\text{abs}(\beta_3) \); normalized time\( T = (t - \beta_1 z)/T_0 \); the plotting of interaction at different values of \( q_0 \) are shown from figure (1-9).

1. For \( r = 1 \text{mw} \) and \( q_0 = 0 \text{ps} \)

![Fig. 1: Two soliton pulse having relative separation \( q_0 = 0 \text{ps} \)](image)

In the figure (1), it is clearly shown that at \( q_0 = 0 \text{ps} \), pulses are completely merged into a single pulse and create the largest value of inter symbol interference.

2. For \( r = 1 \text{mw} \) and \( q_0 = 1 \text{ps} \)
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Fig. 2: Two soliton pulse having relative separation $q_0=1.0\text{ps}$

For the relative separation $q_0=1\text{ps}$, the two pulses gets collapsed as shown in figure (2). So in this case it also has very large inter symbol interference.

3. For $r=1\text{mw}$ and $q_0=1.5\text{ps}$

Fig. 3: Two soliton pulse having relative separation $q_0=1.5\text{ps}$

For the relative separation $q_0=1.5\text{ps}$ and the two pulses are collapsed as shown in figure (3), so in this case there is less inter symbol interference as compared to $q_0=1\text{ps}$

4. For $r=1\text{mw}$ and $q_0=2.5\text{ps}$

Fig. 4: Two soliton pulse having relative separation $q_0=2.5\text{ps}$

For the relative separation $q_0=2.5\text{ps}$ and the two pulses are collapsed as shown in figure (4). So in this case there is less inter symbol interference as compared to $q_0=1.5\text{ps}$

5. For $r=1\text{mw}$ and $q_0=3.5\text{ps}$

Fig. 5: Two soliton pulse having relative separation $q_0=3.5\text{ps}$

For the relative separation $q_0=3.5\text{ps}$ and the two pulses are collapsed as shown in figure (5). So in this case there is less inter symbol interference as compared to $q_0=2.5\text{ps}$

6. For $r=1\text{mw}$ and $q_0=4.0\text{ps}$

Fig. 6: Two soliton pulse having relative separation $q_0=4.0\text{ps}$

For the relative separation $q_0=4\text{ps}$ and the two pulses are collapsed as shown in figure (6). So in this case there is less inter symbol interference as compared to $q_0=3.5\text{ps}$

7. For $r=1\text{mw}$ and $q_0=4.5\text{ps}$
For the relative separation $q_0=4.5\text{ps}$ and the two pulses are collapsed as shown in figure (7). So in this case there is less inter symbol interference as compared to $q_0=4.0\text{ps}$

8. For $r=1\text{mw}$ and $q_0=5.0\text{ps}$

For the relative separation $q_0=5\text{ps}$ and the two pulses are collapsed as shown in figure (8). So in this case there is less inter symbol interference as compared to $q_0=4.5\text{ps}$

9. For $r=1\text{mw}$ and $q_0=6.0\text{ps}$

For the relative separation $q_0=6\text{ps}$ and the two pulses are separated as shown in figure (9). So in this case there is zero inter symbol interference.

3. CONCLUSION:

In this paper we have demonstrated that if we want to transmit train of soliton pulses in the channel having initial separation less than $q_0=6\text{ps}$ between the pulses, we get intersymbol interference. So the minimum of $q_0=6\text{ps}$ initial normalized separation is required to get zero inter symbol interference and having this separation we receive undistorted output pulse. Overall we conclude that this technique is very important for transmitting high information with least loss through the communication channel.

REFERENCES


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