Appendix A

Condition for the Sum of Two Displaced Gaussian Pulses to Exhibit a Single Peak

Recalling from (4.18) that the mathematical of the pulse consisting of twin displaced Gaussian pulses is given by

\[
q(A_n) = A_0 \left[ \exp \left( -\frac{(A_n + \delta/2)^2}{2a_n^2} \right) + \exp \left( -\frac{(A_n - \delta/2)^2}{2a_n^2} \right) \right].
\]

(A.1)

The condition at which a resultant pulse has a single peak is that \( \frac{\partial q(A_n)}{\partial A_n} = 0 \) has only a single solution at \( A_n = 0 \). By using (A.1), \( \frac{\partial q(A_n)}{\partial A_n} \) is given by

\[
\frac{\partial q(A_n)}{\partial A_n} = -A_0 \left\{ (A_n + \delta/2) \exp \left( -\frac{(A_n + \delta/2)^2}{2a_n^2} \right) + (A_n - \delta/2) \exp \left( -\frac{(A_n - \delta/2)^2}{2a_n^2} \right) \right\}.
\]

(A.2)

By setting \( \frac{\partial q(A_n)}{\partial A_n} = 0 \), (A.2) becomes

\[
0 = (A_n + \delta/2) \exp \left( -\frac{(A_n + \delta/2)^2}{2a_n^2} \right) + (A_n - \delta/2) \exp \left( -\frac{(A_n - \delta/2)^2}{2a_n^2} \right).
\]

(A.3)

By inspection, it is clearly seen from (A.3) that \( A_n = 0 \) always satisfies the equality in (A.3) regardless of \( \delta \) and \( a_n \). This is location of the peak in the case of a single-peak pulse. In that case, \( A_n \) other than \( A_n = 0 \) does not satisfies the equality in (A.3). For the case of a two-peak pulse, the other two values of \( A_n \) that satisfy the equality in (A.3) for given \( \delta \) and \( a_n \) are the locations of the peaks in time. Unfortunately, those \( A_n \) cannot be solved analytically in closed form from (A.3). Note that (A.3) can also be written in the other form as

\[
0 = \left( T_n + \frac{\phi}{2} \right) \exp \left( -T_n\phi \right) + \left( T_n - \frac{\phi}{2} \right)
\]

(A.4)

where

\[ T_n \]
\[ T_n = \frac{\tau_n}{a_0} , \quad \text{(A.5)} \]

and

\[ \phi = \frac{\delta}{a_0} . \quad \text{(A.6)} \]

In order to determine the condition at which the resultant pulse has only a single peak, (A.4) has to be evaluated numerically. When \( \phi \) is sufficiently small, the resultant pulse will have only a single peak. This can be intuitively understood from the fact that when \( \phi = 0 \), those two Gaussian pulses are collocated, and the sum of two collocated Gaussian pulses is still a Gaussian pulse, which has only a single peak. Consequently, when (A.4) is considered, there exists the maximum value of \( \phi \) for which only \( T_n = 0 \) can satisfies (A.4). The maximum value of \( \phi \) can be numerically evaluated by considering the right hand side (RHS) of (A.4). The RHS of (A.4) as a function of \( T_n \) at various values of \( \phi \) is plotted as shown on Fig. A.1. It is clearly seen from Fig. A.1 that at small \( \phi \) (\( \phi = 1 \) for example), the RHS of (A.4) crosses zero only at \( T_n = 0 \). When \( \phi \) is larger than 2, the RHS of (A.4) always crosses zero three times. That is, when \( \phi \) is larger than 2, the sum of two Gaussian pulses yields a two-peak pulse. The locations (other than \( T_n = 0 \)), at which the RHS of (A.4) crosses zero, are in fact the locations of the peaks when \( \phi > 2 \). Note that when \( \phi = 2 \), \( T_n = 0 \) is the inflection point of the RHS of (A.4).
Fig. A.1: Numerical evaluation of the RHS of (A.4) as a function of $T_n$ at different values of $\phi$. 

Appendix A
References


References


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Vita

Virach Wongpaibool was born in Bangkok, the capital of Thailand, on January 21, 1972. In 1990, he was admitted to the college of engineering, Chulalongkorn University, Bangkok. After four years of intense study, he graduated with a Bachelor Degree (Second Class Honors) in electrical engineering. His major is telecommunications. In 1994, he joined Advanced Info Service PCL, the company that provides wireless telephone service in Thailand. He worked as an engineer in the GSM base station installation department where he gained valuable experience in wireless communication field. He joined Virginia Polytechnic Institute and State University in August 1996 to pursue his graduate studies. He conducts research under the advisory of Prof. Ira Jacobs who has motivated him to be interested in optical fiber communications. He received his M.S. degree in electrical engineering in September 1998. In 2000, he came back to Virginia Tech. to pursue his Ph.D. degree. His Ph.D. dissertation is still focused on the optical fiber communications. His research interests are optical modulation formats, and the design of high-speed optical communication systems. Virach is a student member of IEEE and OSA.