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Mathematical Model for Asymmetrical Pulses Passing through Active Medium

This study presents basic aspects of discrete asymmetrical pulses generated by using delay operator applied on certain dynamical system. It is shown that the asymmetry of position for significant values inside the pulse time interval can be modelled using a binomial written as {(a+b)}^n, with a≠b and a+b=1.
This binomial model proves useful when pulses become shorter each time when they pass through a certain material medium. In a previous study [1], a certain delay operator denoted as τ has been included in a binomial as (1+τ)^n. A certain dynamical system has been considered to start from an initial state S_i at zero-time moment. Describing the interaction generating pulses by an operator (1+τ)^n acting upon the initial state S_i of this system, it was shown that the corresponding time evolution of this system could be characterized by a state S determined through power n of this binomial applied upon the initial state. Connecting the coefficient multiplying power k of τ to a certain amplitude, a discrete-time function is generated which can be extended through interpolation in order to obtain a continuous function (easily to be represented graphically).
In another study [2] a graphical method for determining the parameters of this model based on tangent line in inflection point has been presented.
These previous studies are continued within this paper by extending the research upon asymmetrical pulses. It is shown how the point of maximum amplitude is shifted as related to the middle of the interval on which the pulse is defined as function of the difference a-b. The inflexion points k_{1,2}are determined for the case a≠b and the derivative of the pulse amplitude in these inflexion points (for a discrete function extended by continuity) is computed. It is shown that the derivatives in these points slightly differs to the value 2×Pulse Amplitude (the result previously obtained for symmetrical pulses) for great values of exponent n, but the difference becomes significant for lower values of n.
For a preliminary analysis of asymmetrical pulses, it is shown that from ratio k_{1,2}/n can be used for determining δ=(b-a)/2, and the difference D=k_2-k_1 can be further used for determining n. It must be mentioned that finally an optimization procedure should be performed (by searching the best possible values for a, b, n for validating the combinatorial model (the first approximation can yield for a, b, n values which differ to the real ones). An additional method based on a linear dependence of a Certain Response Time Constant when passing from a certain amplitude to the subsequent one is also presented. for justifying modelling supplementary asymmetries of derivatives (slopes) situated left/right as related to the point of maximum.
This asymmetrical binomial model provides a good extension for modelling pulses which time length varies when passing through active medium to the case when the symmetrical pattern of pulse amplitudes along the time axis is also altered.
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[1] B. Dumitru and all, Scientific Bulletin Politehnica University, Bucharest, Series A-Applied Mathematics and Physics. 85 (1), 189 (2023)\
[2] C.Toma, Scientific Bulletin Politehnica University, Bucharest, Series A-Applied Mathematics and Physics, 86 (2), 147 (2024)

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