Temporal Kurtosis of Electromagnetic Pulsed Waves Propagating Through the Turbulent Ionosphere

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It is well known that electromagnetic waves will suffer distortions in propagation through the turbulent ionosphere, such as wave propagation through the satellite-to-ground path. As a result, the energy distributions of transmitted pulse waves will be altered.

The kurtosis reflects the concentration of energy near the mean time of arrival. The fourth temporal moment measures the kurtosis of a pulse, the degree to which the distribution is peaked. The statistical moments with even number order can represent the degree of peaked distribution of a waveform. Although the second central moment, that is variance, can represent the kurtosis to some extent, sometime the variance is same while the kurtosis is different. As a result, considering the complexity of evaluation, the fourth central moment is used to represent the kurtosis of a waveform usually. The actual numerical measures of these characteristics are standardized to eliminate the physical units through dividing by an appropriate power of the standard deviation, as in the following equation dividing by τ^4,

$$K = \frac{<\overline{\overline{M(4)}}>}{\tau^4} - 3, \qquad (1)$$

where τ^2 is the mean square pulse width. The larger the magnitude of kurtosis is, the sharper the distribution will be, vice versa. $K = 0$ is for a normal (or Gaussian) distribution. If K>0, it means that the distribution is sharper than Gaussian distribution, otherwise K<0 means that it is flatter than Gaussian distribution.

Because the derivation of the fourth order temporal moment is so tedious that only the numerical calculation has been given here for a Gaussian pulse propagating through the turbulent ionosphere. The result shows that the kurtosis is positive, which reflects the received pulse shape is flatter than its original shape.