Appendix A
Extracting Effective PJ and RJ Components from Jitter Histogram

This appendix describes how to extract effective sinusoidal and random components from the jitter histogram. The jitter histogram, which represents the jitter Probability Density Function (PDF), is commonly used for characterizing the jitter. In order to estimate the BER when both sinusoidal and random components are present and contributing to errors, the PDF of the sum of these components should be known. The PDF of the sum of two random variables is the convolution of the individual PDFs. However, there is no closed-form expression for the convolution of a sinusoidal PDF and a Gaussian PDF. Therefore, we can approximate the total jitter PDF using the double delta model. Figure A.1 shows the convolution of a sinusoidal distribution and a Gaussian distribution. Figure A.1a illustrates the case when the random term is dominant, and Fig. A.1b shows the case when the sinusoidal term is dominant.

When RJ is dominant, the distribution follows the Gaussian distribution. On the other hand, when the sinusoidal term is dominant, the jitter distribution has two peaks.

Given a jitter histogram, in order to separate the jitter components, we can assume the tail part of the given distribution is mostly determined by the random component. Then, fitting it with a Gaussian curve would result in the rms value of the random component, as illustrated in Fig. A.2. The distance between the means of these two fitted Gaussians, $2A_{eff}$, gives the effective peak-to-peak amplitude of the PJ, which can be treated as the distance between two Dirac delta functions [14]. Note that this value is different from the injected peak-to-peak amplitude of the PJ [27].

We ran MATLAB simulations to quantify the variations of A_{eff} and σ_{eff} as a function of the ratio of the amount of RJ to the amount of the PJ. First, we computed the convolution of a sinusoidal PDF and a Gaussian PDF by varying the rms value of the random component with a fixed amount of PJ. Using the tail fitting algorithm described in [14], we calculated the A_{eff} and σ_{eff}. Figure A.3 shows the simulation results as a function of the ratio of the rms value of RJ, σ_{RJ}, to the rms value of PJ, σ_{PJ}. Figure A.3(a) shows the RJ rms error normalized with respect to σ_{PJ}, which is defined as:

$$\sigma_{RJ\_err} = \sqrt{{\sigma_{eff}}^2 - {\sigma_{RJ}}^2}$$

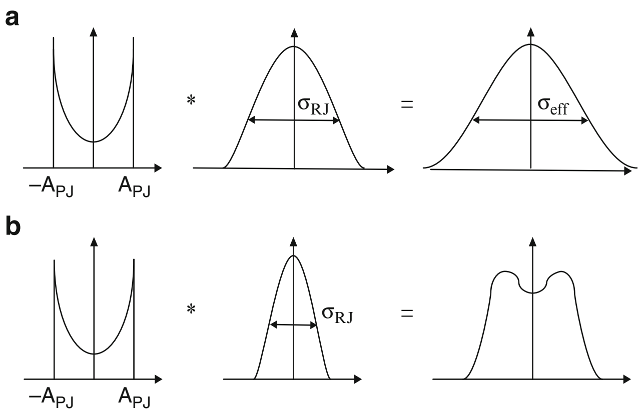

Fig. A.1 The convolution of two PDFs: (**a**) when random distribution is dominant, (**b**) when sinusoidal distribution is dominant

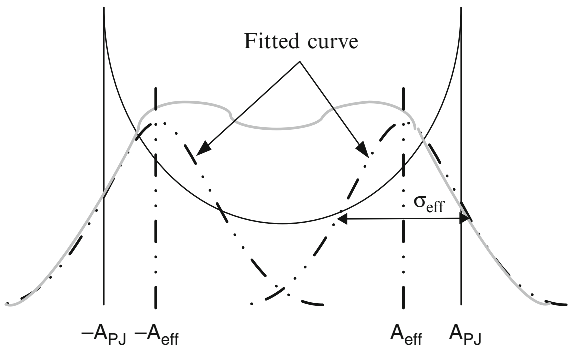

Fig. A.2 Tail fitting to the total jitter distribution

Figure A.3(b) shows the ratio of A_{eff} to A_{PJ} with respect to the ratio of σ_{RJ}/σ_{PJ}. Based on the Fig. A.3, the characteristics of σ_{eff} and A_{eff} can divide into two cases depending on the σ_{RJ}/σ_{PJ}.

1. When $\sigma_{RJ}/\sigma_{PJ} > 1$ (the case illustrated in Fig. A.1a)

In this case, the ratio of the RJ rms error to the rms value of PJ approaches one, which means the effective rms value is increased by the amount of the rms value of the PJ. In addition, A_{eff} is almost zero. Thus, the total jitter can be treated as pure random jitter (i.e. $A_{eff} = 0$), which has the following rms value:

$$\sigma_{eff} = \sqrt{{\sigma_{RJ}}^2 + {\sigma_{PJ}}^2}. \tag{A.1}$$

2. When $\sigma_{RJ}/\sigma_{PJ} < 1$ (the case illustrated in Fig. A.1(b))

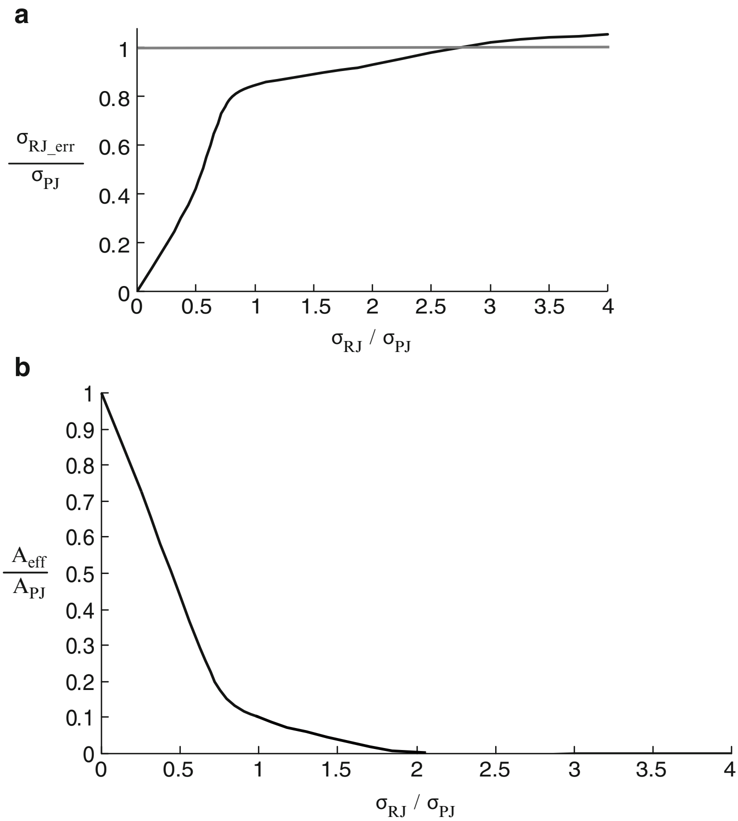

Fig. A.3 Simulation results of tail fitting: (**a**) RJ rms error, (**b**) effective PJ amplitude

Both of $\sigma_{RJ\_err}/\sigma_{PJ}$ and A_{eff}/A_{PJ} have an almost linear relationship with σ_{RJ}/σ_{PJ}. Thus, based on the two curves in Fig. A.3, we can easily derive the following equations to calculate A_{eff} and σ_{eff}:

$$A_{eff} = \left(1 - 0.9 \cdot \frac{\sigma_{RJ}}{\sigma_{PJ}}\right) \cdot A_{PJ}. \tag{A.2}$$

$$\sigma_{eff} = \sqrt{{\sigma_{RJ}}^2 + (0.84 \cdot \sigma_{RJ})^2}. \tag{A.3}$$

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