APPLICATION NOTE

Peak-to-Peak Jitter Calculations

Introduction

A standard deviation of a statistical population or data set is the square root of its variance. A standard deviation is used to calculate the probability of an anomaly or to predict a failure. Many times, the term “root mean square” (RMS) is used synonymously for standard deviation. This is accurate when referring to the square root of the mean squared deviation of a signal from a given baseline and when the data set contains a Gaussian distribution with no deterministic components. A low standard deviation indicates that the data set is close to the mean with little variation. A large standard deviation indicates that the data set is spread out and has a large variation from the mean.

Associating a Bit Error Ratio (BER) when Specifying a Peak-to-Peak Jitter Limit

A standard deviation is required when calculating peak-to-peak jitter. Since true peak-to-peak jitter is random and unbounded, it is important to always associate a bit error ratio (BER) when specifying a peak-to-peak jitter limit. Without it, the specification does not have a boundary and will continue get larger with sample size. Given that a BER is application specific, many frequency timing devices specify jitter as an RMS. This allows the peak-to-peak jitter to be calculated for the specific application and BER requirement. Because a standard deviation is the variation from the mean of the data set, it is important to always calculate the peak-to-peak jitter using the typical RMS value.

Table 1 shows the BER with its appropriate RMS Multiplier. There are two columns for the RMS multiplier: one should be used if the signal is data; the other should be used if the signal is a repetitive clock signal. The difference between the two is the data transition density (DTD). The DTD is the number of rising or falling transitions divided by the total number of bits. For a clock signal, they are equal, hence the DTD is 1. For Data, on average, most common encoding standards have a 0.5 DTD.

Once the BER is chosen, there are two circumstances to consider. Is the data set purely Gaussian or does it contains any deterministic component? If it is Gaussian, then the peak -to-peak jitter can be calculated by simply multiplying the RMS multiplier with the typical RMS specification. For example, if a 10^{-12} BER is required for a clock signal, multiply 14.260 times the typical jitter specification:

Jitter (Peak to Peak) = RMS Multiplier x RMS (typical)

Table 1: BER with its Appropriate RMS Multiplier

BER	RMS Multiplier Data, “DTD=0.5”	RMS Multiplier Clock, “DTD=1”
10^{-3}	6.180	6.582
10^{-4}	7.438	7.782
10^{-5}	8.530	8.834
10^{-6}	9.507	9.784
10^{-7}	10.399	10.654
10^{-8}	11.224	11.462
10^{-9}	11.996	12.218
10^{-10}	12.723	12.934
10^{-11}	13.412	13.614
10^{-12}	14.069	14.260
10^{-13}	14.698	14.882
10^{-14}	15.301	15.478
10^{-15}	15.883	16.028

If the dataset contains deterministic components, then the random jitter (R_J) and deterministic jitter (D_J) must be separated and analyzed separately. R_J, also known as Gaussian jitter, is not bounded and the peak to peak will continue to get larger as the sample size increases. Alternatively, peak-to-peak value of D_J is bounded and can easily be observed and predicted. Therefore, the peak to peak jitter for the random component must be added to the deterministic component. This is called total jitter (T_J).

Total Jitter (Peak-to-Peak) = [RMS Multiplier x Random Jitter (R_J)] + Deterministic Jitter (D_J)

This calculation is not specific to one type of jitter classification. It can be used to calculate BER on various types of RMS jitter. It is important that the user understands their jitter requirement to ensure they are calculating the correct BER for their jitter requirement.

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