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Jitter and wander accumulation in digital networks

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NOTES

1 Supplement 36 to the G-series Recommendations was approved in Melbourne (1988) and published in Fascicle III.5 of the *Blue Book*. This file is an extract from the *Blue Book*. While the presentation and layout of the text might be slightly different from the *Blue Book* version, the contents of the file are identical to the *Blue Book* version and copyright conditions remain unchanged (see below).

2 In this Supplement, the expression "Administration" is used for conciseness to indicate both a telecommunication administration and a recognized operating agency.

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As an example of what these factors mean consider the white FM noise component in Figure I-2 (plus sign tagged data). For the 10 000 second lag, the square root of the sample variance is 8×10^{-12}. The 90% confidence interval for the true variance is bounded by the confidence factors multiplied by the sample variance. This leads to the square root of the Allan variance being bounded between 6.9×10^{-12} and 9.8×10^{-12} with a 90% confidence level.

Reference

[1] BARNES (J. A.): Data Analysis and Confidence Intervals, *NBS Time and Frequency Seminar Notes*, chapter 6, August, 1986.

Supplement No. 36

JITTER AND WANDER ACCUMULATION IN DIGITAL NETWORKS

(Referred to in Recommendation G.824)

The present Supplement describes a model which has been used to compute jitter/wander accumulation in digital networks arising from cascaded digital regenerators and asynchronous digital multiplexes. This model does not include other sources of wander generation; e.g., environmental, disruptions in synchronization reference distribution, etc.

1 Jitter and wander accumulation – Digital regenerator component

The most widely used model of regenerator jitter/wander accumulation, attributed to Chapman [1], treats the regenerator as linear, shift-invariant system. In order to compute the accumulated jitter/wander after N cascaded regenerators, intrinsic regenerator jitter/wander is categorized in terms of "random" and "systematic" components. Chamzas model of regenerator jitter/wander accumulation [2] addresses how stochastic variations in regenerator retiming circuits affect jitter/wander accumulation. The results of this study demonstrate that use of the appropriate *mean* jitter/wander transfer characteristic in the identical regenerator accumulation model, summarized above, provides a very good estimate to jitter/wander accumulation computed assuming a stochastic variation of retiming circuits.

Using Chapman's model for a chain of N *identical* regenerators, defining $H_1(j\omega)$ as the jitter/wander transfer characteristic for one regenerator, and redefining the random and systematic components as completely uncorrelated and correlated components, respectively,

– the power spectral density of the random jitter/wander component is:

$$\Phi_N^R(\omega) = \Phi_{i1}^R |H_1(j\omega)|^2 \frac{1 - |H_1(j\omega)|^{2N}}{1 - |H_1(j\omega)|^2} \quad (1)$$

where Φ_{i1}^R is the constant, internally generated, random (pattern independent plus uncorrelated pattern dependent) jitter/wander power spectral density for one regenerator.

– the power spectral density of the systematic jitter/wander component is:

$$\Phi_N^S(\omega) = \Phi_{i1}^S |H_1(j\omega)|^2 \frac{|1 - H_1(j\omega)^N|^2}{|1 - H_1(j\omega)|^2} \quad (2)$$

where Φ_{i1}^S is the constant, internally generated, systematic (correlated pattern dependent) jitter/wander power spectral density for one regenerator. Φ_{i1}^R and Φ_{i1}^S can be estimated from practical measurements based upon the regenerator's jitter/wander response to short and long word lengths from a pattern generator, and correlation studies.

When there is no peaking in the regenerator jitter/wander transfer characteristic, the systematic jitter/wander accumulates much more rapidly than the random jitter/wander [1], [4], [5]; as a result, random jitter/wander accumulation is often ignored. However, for a large number of regenerators with peaking in the jitter/wander transfer characteristic, the total jitter/wander accumulation can be dominated by the random component.

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