operation:

Ideal

$$\sigma_{TIE} = \sqrt{3\,\sigma^2_{,}(\tau = \tau)\cdot\tau}$$

Stressed

$$\sigma_{TIE} = \sqrt{\sigma^2_{\beta\iota\alpha\sigma} + \sigma^2_{,}(\tau = \tau)\cdot\tau}$$

Holdover

$$\sigma_{TIE} = \frac{\Delta}{2}\cdot\tau^2 + \sqrt{\sigma^2_{\beta\iota\alpha\sigma} + \sigma^2_{,}(\tau = \tau)\cdot\tau}$$

where,

σ_{TIE} ισ τηε στανδαρδ δεϖιατιον οφ τηε ρελατιϖε τιμε ιντερϖαλ ερρορ οφτηε χλοχκ ουτπυτ χομπαρεδ το τηε ρεφερενχε οϖερ τηε οβσερϖατιον τιμε τ.

σ,(τ) ισ τηε τωο σαμπλε στανδαρδ δεϖιατιον δεσχριβινγ τηε ρανδομ φρεθυενχψ φλυχ τυατιον οφ τηε χλοχκ, ανδ

$\sigma_{\beta\iota\alpha\sigma}$ δεσχριβεσ τηε τωο σαμπλε στανδαρδ δεϖιατιον οφ τηε φρεθυενχψ βιασ.

3.Guidelines concerning the measurement of jitter and wander

Verification of compliance with jitter and wander specifications requires standardized measurement methodologies to eliminate ambiguities in the measurements and in the interpretation and comparison of measurement results. Guidance concerning the measurement of jitter and wander is contained in Supplement No. 35.

bandwidth of the PLL. The output of the clock can be viewed as a superposition of the high frequency noise of the local oscillator riding on the low frequency portion of the input reference signal. In phase locked operation the high frequency noise must be bounded, and is uncorrelated (white) for large observation periods relative to the bandwidth of the phase locked loop.

Under ideal conditions, the only non-zero parameter of the model is the white noise PM component.

1.2 Stressed operation

In the presence of interruptions, the stability of the output timing signal behaves as a white noise FM process as the observation period is increased to be within the tracking bandwidth of the PLL. The presence of white noise FM can be justified based on the simple fact that in general, network clocks extract time interval, rather than absolute time from the time reference. An interruption is by nature a short period during which the reference time interval is not available. When reference is restored there is some ambiguity regarding the actual time difference between the local clock and the reference. Depending on the sophistication of the clock phase build-out there can be various levels of residual phase error which occur for each interruption. There is a random component which is independent from one interruption event to the next which results in a random walk in phase, i.e. a white noise FM noise source.

In addition to the white noise FM component, interruption events can actually result in a frequency offset between the clock and its reference. This frequency offset (y_{bias}) results from a bias in the phase build-out when reference is restored. This is a critical point. The implications of this effect are that in actual network environments there is some accumulation of frequency offset through a chain of clocks. Thus, clocks controlled by the same primary reference clock are actually operating plesiochronously to some degree.

To summarize, under stress conditions the non-zero parameters of the clock model are the white noise FM component (e_{fm}) and the frequency offset component (y_{bias}). The stressed category of operation reflects a realistic characterization of what "normal" operation of a clock is.

1.3 Holdover operation

In holdover, the key components of the clock model are the frequency drift (D) and the initial frequency offset (y_{bias}). The drift term accounts for the significant ageing associated with quartz oscillators. The initial frequency offset is associated with the intrinsic setability of the local oscillator frequency.

2. Relationship of slave clock model to TIE performance

It is useful to consider the relationship between the clock model and the Time Interval Error (TIE) that would be expected. It is proposed that the two sample Allan variance be used to describe the stochastic portion of the clock model. The following equations apply for the three categories of

ANNEX

(to Recommendation G.812)

Characterization of slave clock phase stability

1.The slave clock model is described by the following equation:

$$x(t) = y_{bias} \cdot t + \frac{D}{2} \cdot t^2 + e_{pm}(t) + \int_{\tau=0}^{\tau=\tau} e_{fm}(\tau)\delta\tau$$

where,

$x(t)$ is the phase-time output relative to the reference input (dimensions of time)

y_{bias} is a residual fractional frequency offset which can arise from disruption events on the reference input (dimensionless)

D is the linear frequency drift component when the clock is in holdover condition (dimension 1/time)

$e_{pm}(t)$ is a white noise phase modulation (PM) component associated with the short-term instability of the clock (dimension time)

$e_{fm}(t)$ is a white noise fractional frequency modulation (FM) component associated with the disruption process of the reference (dimensionless)

The clock model is best understood by considering the three categories of clock operation:

- ideal operation;
- stressed operation;
- holdover operation.

1.1Ideal operation

For short observation intervals outside the tracking bandwidth of the PLL, the stability of the output timing signal is determined by the short term stability of the local synchronizer time base. In the absence of reference disruptions, the stability of the output timing signal behaves asymptotically as a white noise PM process as the observation period is increased to be within the tracking