**Real-Time Wander Measurement**

**What is Wander?**
Wander is the long-term variation of the signal instantaneous frequency of a digital signal from a reference point. When wander is defined as a slow variation over a long period of time, \( T_{1.101} \) is the measurement period. When wander is defined as a change in the signal instantaneous frequency over a longer period of time, \( T_{1.101} \) is the measurement period.

**What is the difference between Wander and Jitter?**
Wander is a slow phase variation of a clock signal over a long period of time, whereas Jitter is a rapid phase variation of a clock signal over a short period of time. Wander is typically measured in nanoseconds and set to zero at the start of the measurement period. Jitter is typically measured in picoseconds and can be positive or negative.

**Clock Specifications**
- **Frequency Drift Rate**: Frequency drift rate (in ns/s) is the number of phase samples in the measurement period divided by the number of samples.
- **Frequency Offset and Frequency Drift Rate**: Frequency offset is the difference between the actual frequency and the nominal frequency, and frequency drift rate is the rate of change of frequency with respect to time.
- **Phase Variability**: Phase variability is the phase difference between two or more signals, and it can be measured in terms of phase noise, phase error, or phase jitter.

**Wander Standards**
- **ITU-T Recommendations**: ITU-T O.172/G.810
- **IEEE Standards**: IEEE 1588-2008
- **Other Standards**: ISO 1149-4, IEC 61158

**Clock Hierarchy and Synchronization Reference Chain**
- **Reference Clock**: Reference clock is the primary reference frequency source for synchronization.
- **Secondary Clocks**: Secondary clocks are derived from the reference clock and are used to support the synchronization of other devices.
- **Reference Clocks**: Reference clocks are clock signals that are synchronized with a reference frequency source.

**TIE (Time Interval Error)**
TIE can be determined as the time difference between the signal being measured and the reference clock. It is typically measured in nanoseconds and set to zero at the start of the measurement period. TIE can be used to assess the accuracy of the reference clock and to determine the accuracy of other clocks in the network.

**MTIE (Maximum Time Interval Error)**
MTIE is measured as the maximum difference between the actual and nominal time with respect to the reference clock. MTIE can be used to assess the long-term stability of the reference clock and to determine the long-term stability of other clocks in the network.

**Wander Measurements**
- **Clock Stability Measurement**: This measurement evaluates the accuracy of the reference clock over a long period of time.
- **Wander Generation of DUTs (TIE/MTIE/DEV)**
- **Wander Measurement for Synchronous Signals (TIE/MTIE/DEV)**
- **Wander Measurement for Asynchronous Signals (MTIE)**

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