



# Wander measurements with Victoria

The wander of a signal is characterized by a set of basic parameters: TIE, which gives the phase error between the clock and the reference taken; MTIE, which is useful for buffer sizing, giving information about relative frequency offset; and TDEV, which helps diagnose the causes of wander



Application Note ANVAJWTIE21E



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As wander is a slow phase variation, timing circuitry is capable of performing a correct sampling of bits and thus wander does not produce bit errors directly like jitter. However, a network element (NE) cannot filter wander and this is accumulated in the synchronization chain. There may be significant wander between the different signals arriving to a NE, which has to provide large enough buffers to cope with this. At SDH/SONET network nodes, the pointer mechanism allows the buffers to be relatively small but produces pointer jitter at tributary outputs. A compromise has to be found between the above mentioned facts. On the other hand, at the exchange nodes, the only way to cope with the buffers overflow is through controlled slips. Although loss of data frames synchronization or FAS errors are avoided, these slips produce error bursts. Due to these effects, wander has to be limited and quantified in order to compare it with the limits defined by the corresponding recommendations.

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## MEASURING OUTPUT WANDER (TIE)

Output wander can be measured to assess the quality of a clock at the boundaries between two different synchronous networks. This is an absolute measurement: the wander value gives information about the clock degradation when compared with the primary reference.

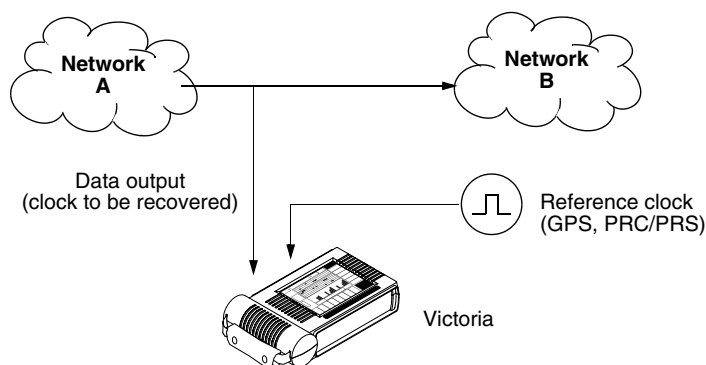


Figure 1

Assessing the clock quality at the interface between two different synchronous networks: wander absolute measurement diagram. Note: PRC/PRS (Primary Reference Clock/Primary Reference Signal).

In the second case the aim is to measure the wander accumulated when a given signal is sent through a network by comparing its clock with that used as a reference. This is a relative measurement: both the network element generating the signal and the wander analyzer are synchronized to the same reference.

## Wander measurements with Victoria

Measuring output wander (TIE)

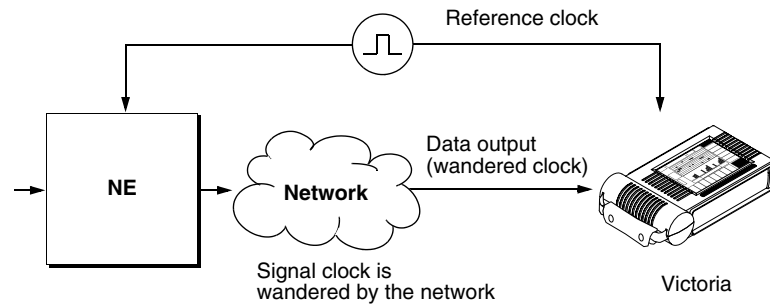


Figure 2

Assessing the wander generated by a network: measurement diagram.

The same application can be particularized to assess the wander introduced by a single NE -i.e. intrinsic wander- (for example, when evaluating a SEC and the reference is an SSU/BITS).<sup>1</sup> In all cases TIE is the basic parameter to be measured, and indicates the phase error amplitude for wander. Victoria gives the instantaneous TIE value and graphically traces the evolution of TIE over time.

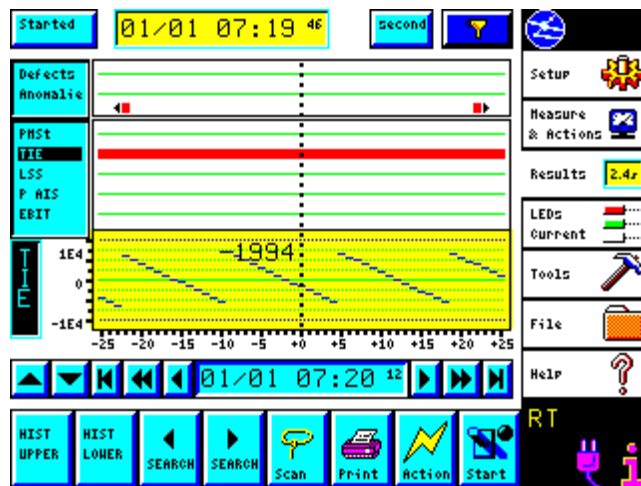


Figure 3

TIE vs. time is also traced by Victoria.

Nowadays video signal channels (e.g. MPEG-2 at 6 Mbit/s) are often transmitted in 140, 45 and 34 Mbit/s streams. Frequency offset and drift in these streams has to be measured at video decoder inputs and compared with the limits defined for PAL or NTSC systems to assess video timing quality. Starting from the TIE value, Victoria is able to

1. SEC (Synchronous Equipment Clock), SSU/BITS (Synchronization Supply Unit/Building Integrated Timing Supply).

calculate the frequency offset (in ppm) of the signal received in respect to its nominal value and the frequency drift (in ppm/s). The instantaneous and maximum values from the start of the measurement are displayed in the corresponding information fields, as shown in the figure below.

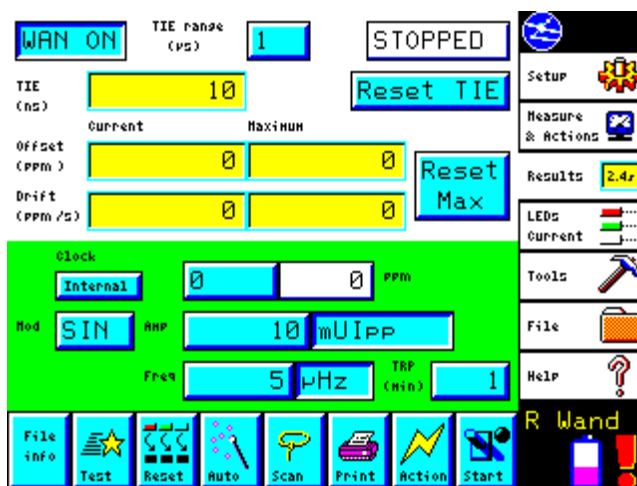


Figure 4 Wander O.172 screen.

## MTIE AND TDEV

Output wander and other wander measurements require not only the phase error amplitude measurement (TIE) but also some other complementary parameters that are calculated from the latter. These parameters are the *Maximum Time Interval Error* (MTIE) and the *Time DEVIation* (TDEV). Many wander requirements for network elements and interfaces are expressed in the corresponding recommendations in terms of MTIE and TDEV so these parameters have to be measured frequently.

### MTIE

Maximum time interval error is calculated from the TIE measurement. It can be described as follows: for a given TIE vs. time measurement, the MTIE is the maximum peak to peak TIE value detected in a time window sliding along all the measurement time. The MTIE value obtained depends on the width  $S$  of the time window.

By defining different time windows, a table or graph with several MTIE( $S$ ) values is obtained from the TIE measurement mentioned.

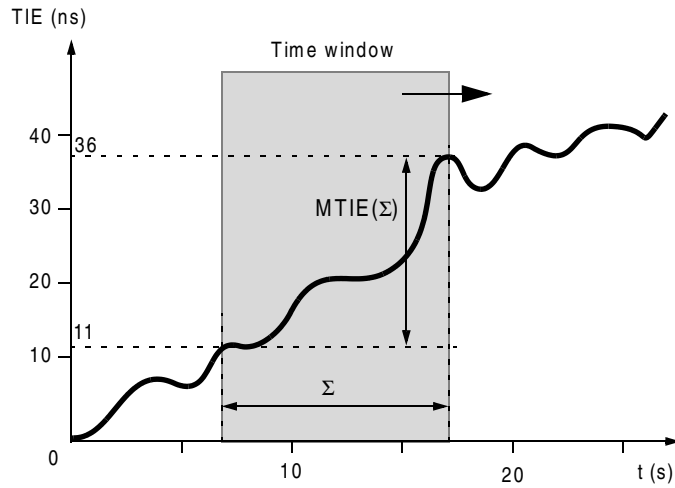


Figure 5 MTIE calculation as defined by ITU-T G.810, ANSI T1.101 and ETS 300 462-1. *t*-axis is the measurement time.

MTIE values are positive, as they are differences between maximum and minimum values. On the other hand, the MTIE function is always increasing, as an MTIE value in respect to a time window width is always included in a wider time window.

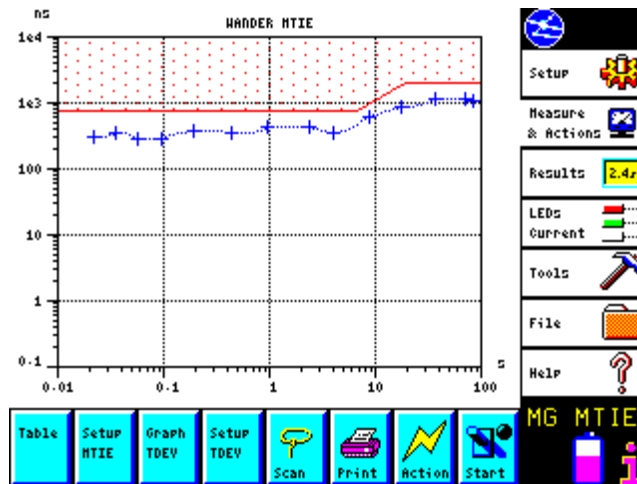


Figure 6 MTIE graph. The corresponding values are also available in the form of a table.

MTIE is the maximum phase error between the clock measured regarding to the reference clock for a given observation time *S*. In addition, MTIE is a measurement of the relative frequency offset<sup>2</sup>. This last meaning has applications, as buffers of *NE* are used to compensate frequency offsets due to pointer adjustments. If the size of a *NE* buffer

is configured according to a specified MTIE value and this value is not exceeded, no buffer overflows will occur (therefore, frame slips will not occur). ITU, ETSI and ANSI recommendations specify MTIE vs. observation interval masks for NE and clock sources.

Victoria is capable of measuring the MTIE and presents the results as a table and graph simultaneously. In addition, predefined MTIE masks can be programmed and saved for pass/fail tests.

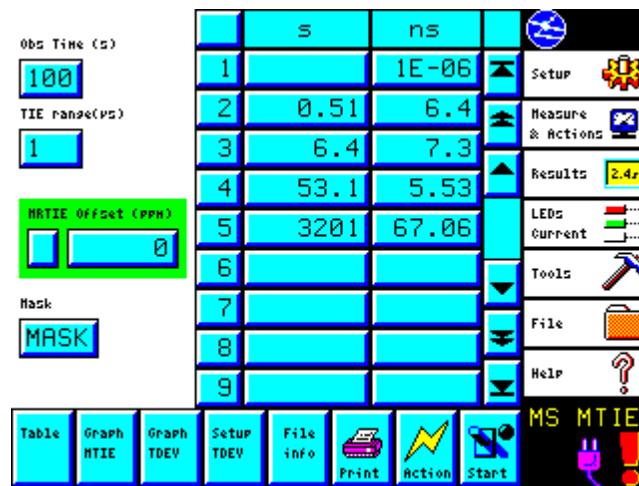


Figure 7 MTIE setup screen.

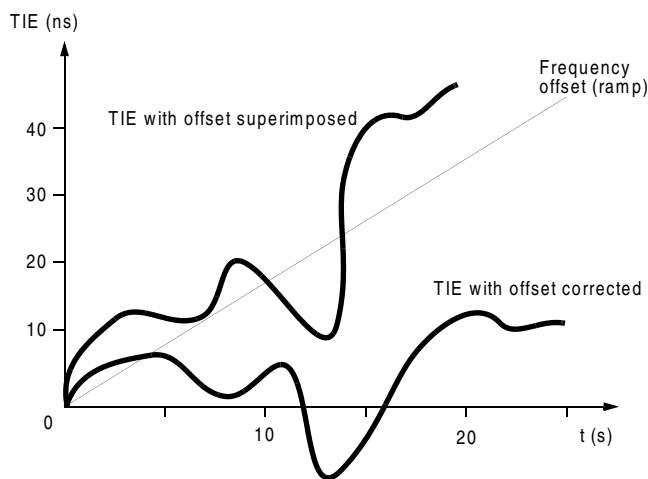
## MRTIE measurements

When a reference clock used for wander measurement is not available, the measurement is performed by using a local clock. This will introduce a frequency offset superimposed as a ramp in the TIE measurement. As MTIE is calculated from TIE samples, this effect will appear in MTIE calculation too. It is necessary to correct it by subtracting the offset from the measurement, to perform a correct

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2.  $MTIE(S)/S$  is approx. equal to  $\Delta f/f$ .

wander *MRTIE* measurement (MTIE relative to a UTC signal). The effect of this subtraction is shown graphically in the figure below.



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Figure 8

*MRTIE measurement: frequency offset correction.*

Victoria can carry out this offset correction on wander measurements. The value to subtract can be easily programmed by the user (see fig. 7).

## TDEV

Time deviation (TDEV) is calculated from the TIE measurement, as is MTIE. Since TIE is an statistical process (random process), TDEV is the typical deviation for every  $S$  value, with  $S$  being defined above. The definition of TDEV allows a subsequent interpretation in which TDEV contains information about the power spectral density of the random phase deviation i.e. how the energy of wander components is distributed along the wander spectrum. For short  $S$  the high-frequency components are assessed; for long  $S$ , the low-frequency components are assessed.

This interpretation of TDEV is useful when diagnosing the causes of a wander impairment. It has been demonstrated that the slope of the curve TDEV( $S$ ) vs.  $S$  tends towards some typical values. Each value is associated to a different wander noise process, and each noise can be related to a wander cause. For example, a slope  $S^2$  indicates wander due to temperature variations, while slopes  $S$  and  $S^{1/2}$  indicate typical noise processes present at different types of oscillators. To sum up, TDEV gives information about frequency drift or about the cause of wander phase modulation. TDEV values are always positive.

As with MTIE, Victoria is capable of measuring the TDEV and presents the results as a table and graph simultaneously. In addition, predefined TDEV masks can be programmed and saved for pass/fail tests. □

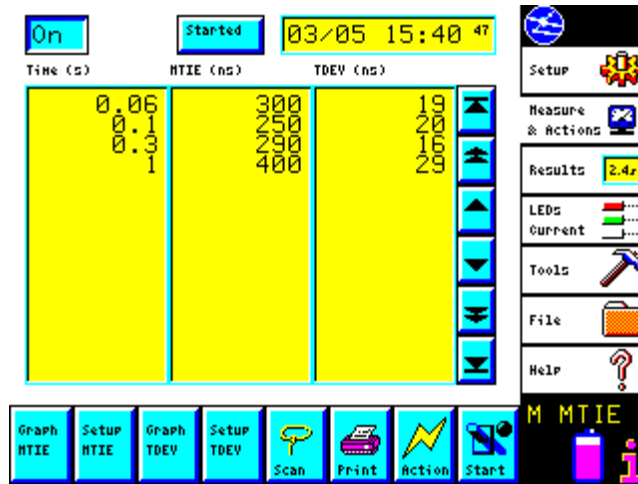


Figure 9

Wander TDEV and MTIE results table.



**TrendCommunications**

Trend Communications SL  
 Pujades, 60  
 08005 Barcelona (Spain)  
 www.trendcomms.com  
 infoline@trendcomms.com

Trend Communications Ltd  
 Knaves Beech Estate  
 Loudwater, High Wycombe  
 Buckinghamshire HP10 9QZ UK

International: .... +44 1628 524977  
 España:..... 93 300 3313  
 UK:..... 01628 524977  
 Deutschland: .... 089 32 30 09 11

Italia: ..... 02 73 91 414  
 France: ..... 01 69 35 54 70  
 India:..... 22 8597 463/4  
 US: ..... 256 461 0790