Comparison of Allan Deviation calculate measures undertaken by TSC

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Resumo: Este artigo mostra os resultados da comparação do desvio de Allan de medidas realizadas com o equipamento analizador de intervalo de tempo TSC - 5110A e foram utilizados os dados de medida de calibração do padrão de freqüência primária e dos clientes do Laboratório Primário de Tempo e Frequência do Observatório Nacional. Uma planilha em Excel foi utilizada para o cálculo do desvio de Allan das medições previstas pela TSC e estes resultados foram comparados com os resultados fornecidos pelo Stable 32, software fornecido com o TSC.

Palavras-chave: Desvio de Allan, Incerteza, Analizador de intervalo de tempo, Padrão de Frequência.

Abstract: This article shows the results of comparing the Allan deviation of measurements taken with the analyzer equipment time interval TSC - 5110A and data were used to measure calibration of primary frequency standard and customer Laboratory of Time and Frequency Primary National Observatory. An Excel spreadsheet was used to calculate the Allan deviation of the measurements provided by the TSC and these results were compared with the results provided by Stable 32 software supplied with the TSC.

Keywords: Allan Deviation, Uncertainty, Time Interval Analyzer, Frequency Standard.

1. INTRODUCTION

Several software do the same job and were developed for been supplied with sophisticated and advanced Time Interval Analyzer around the world, but the details and artifices of calculations at high precision range values were the major motivation of this checking on this paper. There is no special interesting in checking results of specific software. Some of customers' equipments, as a Cesium Beam Tube Frequency Standard and others, from 2009 to 2013 were renamed as "A", "B","C" and "D" respectively. Allan Deviation results obtained from Stable 32 and an Excel plan will be compared and detailed on "Methodology" and "Results" topics.

2. THEORY

Allan's Deviation [3] is a particularity of standard deviation from classical statistics. The variance or standard deviation is used to measure the dispersion of values. The variance is a measure of dispersion of a data set relative to the mean of the set.

However, the variance works with stationary data, where the results should be independent of time. This assumes noise is "white ", which means that its power is equally distributed over the frequency bandwidth of measurement. Due to the intrinsic physical characteristics of oscillators, frequency measures of an oscillator are non-stationary data, they contain components of noise time-dependent and that go into determining the value of the deviation of frequency.

For stationary data, the mean and variance converge to particular values with increasing number of measurements. For non-stationary data, the mean and variance never converge to any particular value. Instead, there is a moving average that varies each time and adds the data to a new measurement, with no convergence to any value. For this reason, the statistic used the Allan variance to characterize the frequency stability

TSC5110A [2] is a Time Interval Analyzer equipment, that provides two-signal difference measure at frame rate range from 1 to 100 samples per second and shows graphically real-time frequency stability using Allan Deviation, phase difference and frequency difference between available channels. The results can be transferred to a computer for plotting graphics in other software platforms as Stable32 and Microsoft Excel.

3. MATH MODELLING

As mentioned in Theory, Allan's Deviation is a particularity of classical statistics's Standard Deviation. Allan's Deviation [3] is the square root of the Allan's Variance and the Standard Deviation is the root square of Variance.

In classical variance, subtract the average value from each value obtained while in the Allan variance [1], subtract each value obtained immediately preceding value. Given that stability reflects fluctuations in frequency and not the offset frequency, the Allan variance of the successive data points are subtracted to remove part of the time-dependent noise

$$\sigma_y(\tau) = \sqrt{\frac{1}{2(m-1)} \sum_{i=1}^{m-1} (\bar{y}_{i+1} - \bar{y}_i)^2} \qquad (1)$$

4. METODOLOGY

In this work, were used to calculate the Allan Deviation values, the Stable 32, of Hamilton Technical Services program for data processing of the measurement system TSC5110A equipment manufacturing Symmetricom, and Microsoft Excel, version 2010 used in this study, considering the same data set, and the same number of samples from the first data point.

The measurement data were analyzed from four users of calibration services Time Service Division (DSHO), now renamed A, B, C and D, respectively using data from calibrations of the years 2009, 2010, 2012 and 2013.

All equipment user's are Time and Frequency Standards of the 133 cesium type, model 5071A, commercial thermical beam, and the values of the Allan deviation were calculated without overlapping.

5. RESULTS

Figure 1 shows the graph plotted in Microsoft Excel (Square) program with data for calculating the same program, in relation to the results declared in the report by Stable 32 (triangle) program for the same user D-2013. The results presented graphically show the consistency of the values found in both programs.

This results reduce the possibility of coarse errors in obtaining the results of the Allan deviation, which could be clearly observed. The results generated by the Microsoft Excel program are equivalent to the data provided by Stable 32 program, according to fig.1 below:

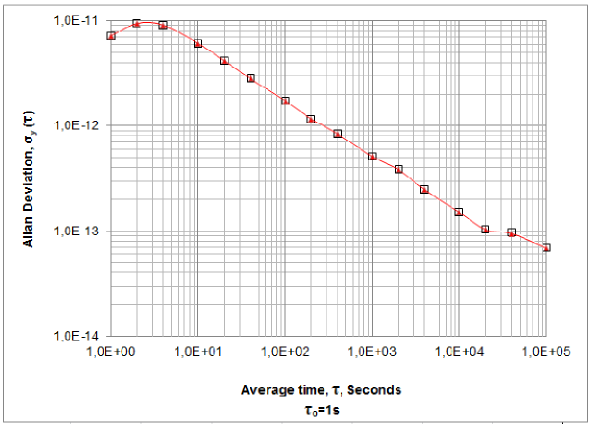

Figure 1: Allan Deviation (Ms. Excel x Stable 32) user D-2013.

In Table 1 it is possible to verify in detail the difference in values between the results generated by the two methods, with comparative summary of the values entered in Figure 1, and the calculated values for each program, normalized by the results of Stable 32.

Table 1 – Comparison Allan Deviation % D-2013

Tau (τ)	# Samples	Sigma EXCEL □	Sigma STABLE 32 ▲	Dif. □/▲ (%)
1,0000E+00	999997	7,1801E-12	7,1801E-12	0,0004%
2,0000E+00	499998	9,4383E-12	9,4383E-12	0,0004%
4,0000E+00	249998	9,1038E-12	9,1039E-12	0,0006%
1,0000E+01	99998	6,1322E-12	6,1321E-12	-0,0009%
2,0000E+01	49998	4,1701E-12	4,1700E-12	-0,0034%
4,0000E+01	24998	2,8199E-12	2,8199E-12	0,0013%
1,0000E+02	9998	1,7353E-12	1,7353E-12	-0,0010%
2,0000E+02	4998	1,1628E-12	1,1665E-12	0,3172%
4,0000E+02	2498	8,3682E-13	8,3799E-13	0,1398%
1,0000E+03	998	5,1277E-13	5,1272E-13	-0,0088%
2,0000E+03	498	3,8269E-13	3,8246E-13	-0,0604%
4,0000E+03	248	2,4806E-13	2,4691E-13	-0,4671%
1,0000E+04	98	1,4997E-13	1,5075E-13	0,5193%
2,0000E+04	48	1,0282E-13	1,0282E-13	0,0025%
4,0000E+04	23	9,7077E-14	9,4141E-14	-3,1189%
1,0000E+05	8	6,9032E-14	6,8993E-14	-0,0571%

6. CONCLUSION

The Microsoft Excel program can be a useful tool in the task of checking and data validation Allan deviation, the values calculated by Tau Stable 32 without overlapping. It can also be used as a validation tool for future programs to be developed for this purpose.

7. REFERENCES

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