Application Notes

Formation of Tolerance Curves and Tolerance Testing using the Real-time Frequency Analyzers Types 2123 and 2133

by Roger Upton

1. Introduction

One of the properties of the Real-time Frequency Analyzer Type 2123/33 is the ability to compare incoming measurement or processed data against tolerance curves. Such tolerance curves can be formed from measured or processed data or entered through the 2123/33 keyboard. This application note describes how such tolerance curves can be formed, the different types of tolerance testing available on the 2123/33, and their use in go/no-go testing.

2. Formation of Tolerance Curves on the 2123/33

Tolerance curves are formed on the 2123/33 using one of the predefined user-definable functions, (UDFs), namely No. 38, Tol. Both measured and processed data can be used as their basis. Fig. 1 shows a set of tolerance curves which have been formed around a single measured spectrum. However, they could equally have been formed around processed data, for instance, the average spectrum calculated from a series of measurements across a large number of test samples. Once the tolerances have been formed, they are stored on disc for future use.

The tolerances are formed by setting the 2123/33 display to show the relevant data, and calling UDF No. 38 to the display set-up. UDF No. 38 is shown in Fig. 2. The spacing of the tolerance curves is controlled by the two constants U-limit and L-limit, (upper limit and lower limit respectively), the values of which are set through the 2123/33 table of constants. In Fig. 2, they have both been set to 10 dB, meaning that the tolerance curves formed will be spaced ± 10 dB around the source data. The

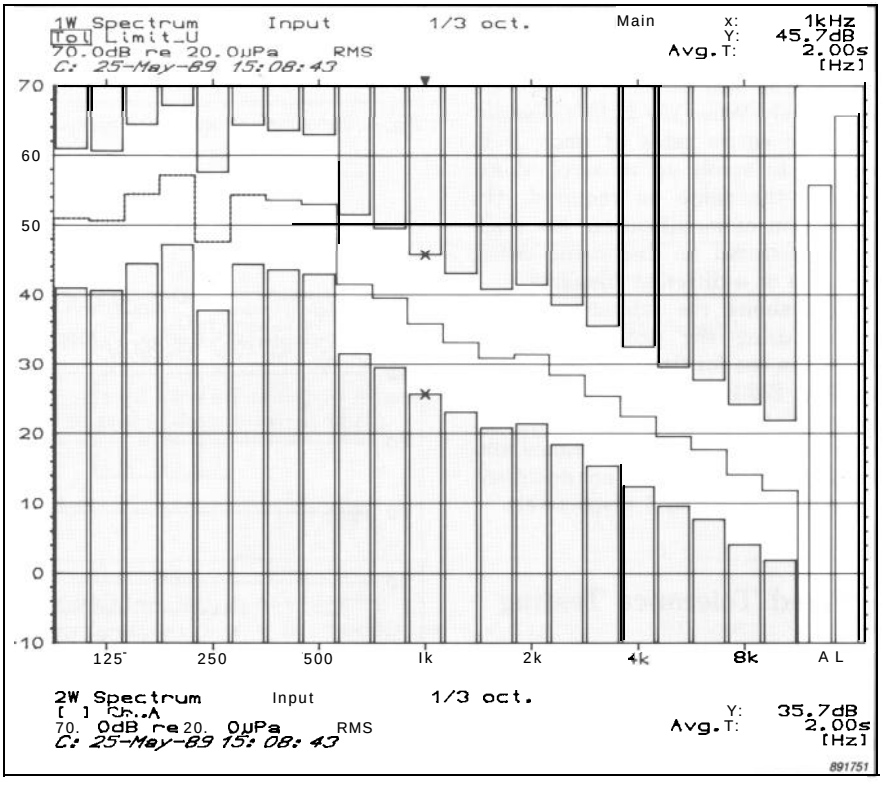

Fig. 1. Formation of tolerance curves around measured data on the 2123133

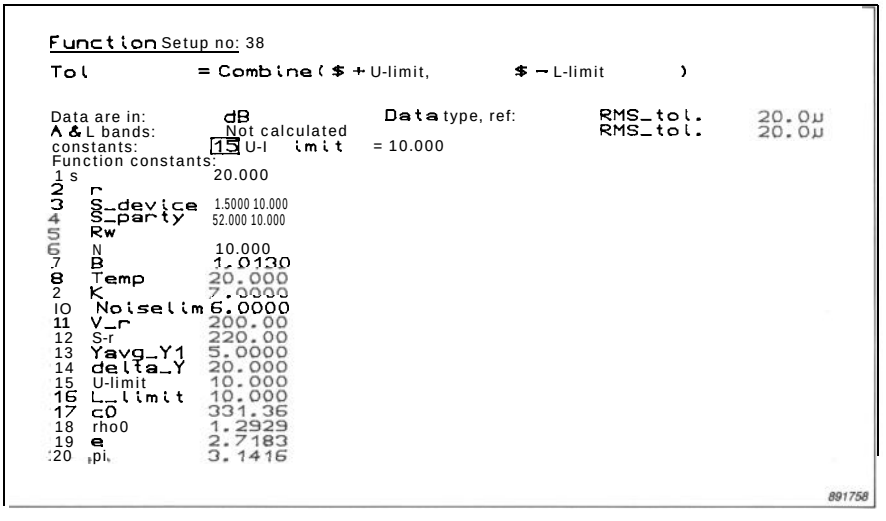

Fig. 2. UDF No.38, used to form the tolerance curves shown in Fig. 1. U_limit and L-limit are defined through the table of constants shown

tolerance curves can then be stored on disc by storing the processed result.

Tolerance curves stored on disc can be modified by recalling the disc-file containing them into a 2123/33 display where there is no UDF active. The most effective means of modification is then to select table format on the 2123/33 display, whereby it will be possible to access the fields containing the upper and lower tolerances and key in the required values via the 2123/33 keyboard. Fig. 3 shows this process taking place. If no upper or lower limit is required, this can be obtained by keying in a suitably large positive or negative number, whereby the 2123/33 will select + ∞ or −∞ respectively. When the 2123/33 cannot show the entire table at once, it is possible to scroll up or scroll down through the table as required. On completion of modification, the disc-file is re-stored on disc using either the same or a different filename.

Fig. 4 shows the tolerance curves, formed using the process just described, in use for fixed tolerance testing. The 2123/33 can carry out three types of tolerance testing, namely, fixed tolerance, aligned tolerance and floating tolerance. These are described in Sections 3, 4 and 5 respectively.

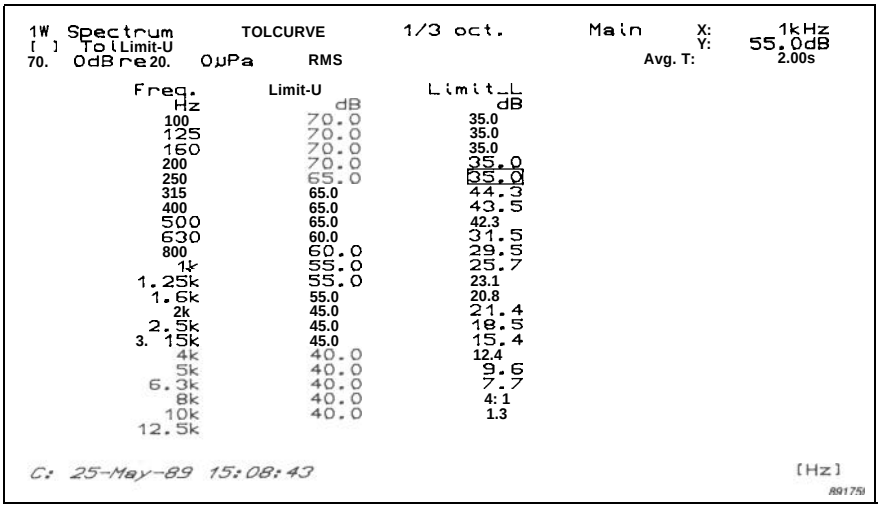

Fig. 3. Table format being used to modify tolerance curves on the 2123133

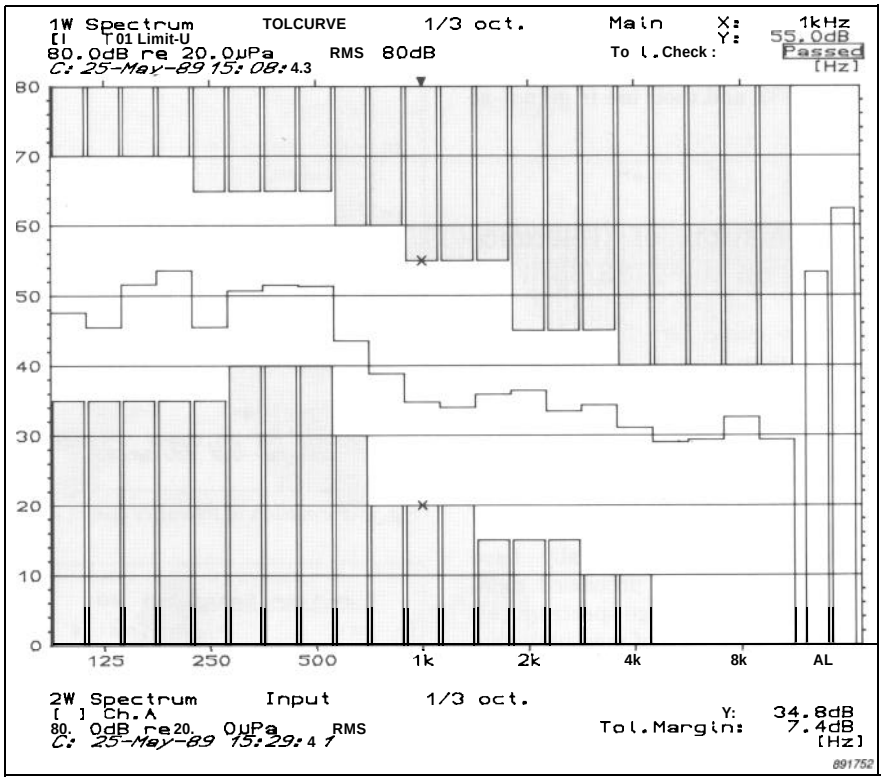

Fig. 4. The tolerance curves resulting from Fig. 3 being used for fired tolerance testing

3. Fixed Tolerance Testing

Fig. 4 illustrates fixed tolerance testing, where the tolerance curves are recalled into one of the 2123/33 displays, (with no UDF being active in that display), the test data being shown in the other display. The two displays are then superimposed with the same ranges and scaling to give a display similar to Fig. 4. Two auxiliary cursor read-outs are then used, namely tolerance check, which indicates pass/fail for the test data, (the pass/fail signal is also available through a connector on the rear of the 2123/33, see Section 7), and tolerance margin, which shows the smallest margin of pass for a test which has passed or the greatest margin of failure for a test which has failed.

The test data presented in tolerance testing can be incoming measurement data or can be processed data. In Fig. 4, the test data is Ch. A autospectrum data. However, the data could also have been processed, for example, to correct for a transducer response, prior to tolerance testing. This would be carried out by calling the relevant UDF into the display showing the test data.

Note that tolerance testing only takes place over the frequency range displayed on the 2123/33 display. This gives a convenient method of restricting the frequency range of testing, where this is required, since it is only necessary to make the desired changes in the two display set-ups being used. This avoids the need for having to change the stored tolerance curves.

(In the above, a superimposed display is used to give the best visual presentation of the data. Note, however, that use of a superimposed display is not strictly necessary, in that a dual display can also be used provided the frequency axes are aligned. Further alignment of the amplitude axes is not strictly necessary, provided they are both calibrated in the same type of units.)

4. Aligned Tolerance Testing

Aligned tolerance testing is used where it is required to move the tolerance curves up or down to match the test data, using one frequency, (or frequency band), as a reference, such that the tolerance curves are aligned to the test data at that frequency. Any frequency, (or frequency band), can be selected for alignment, but it is most frequently set to 1 kHz. Fig. 5 shows aligned tolerance testing in 1/12 octaves. This was obtained by calling the tolerance curves into one display with a UDF for aligned tolerance testing active, and calling the test data into the other display.

The 2123/33 contains a pre-defined UDF for aligned tolerance testing, namely no. 24, Aligned_Tol. This is set up for 1/3 octave tolerance testing, with the alignment taking place in the 1 kHz 1/3 octave. Since the testing being used in Fig. 5 is in 1/12 octaves, and since there is no 1 kHz 1/12 octave in the 2123/33, it is necessary to modify this UDF slightly, such that the tolerances are aligned to the maximum value of the test data in the 972 and 1030 Hz 1/12 octaves, (with further modification, the alignment could be made on the average value). The resulting UDF is shown in Fig. 6. The value of K determines the interval between the test data at 1 kHz and the upper tolerance curve.

Aligned tolerance testing can be carried out on incoming measurement data or on processed data. Where, however, processed data is being tested, it will usually be necessary to modify the UDF used to ensure that alignment is to the right data.

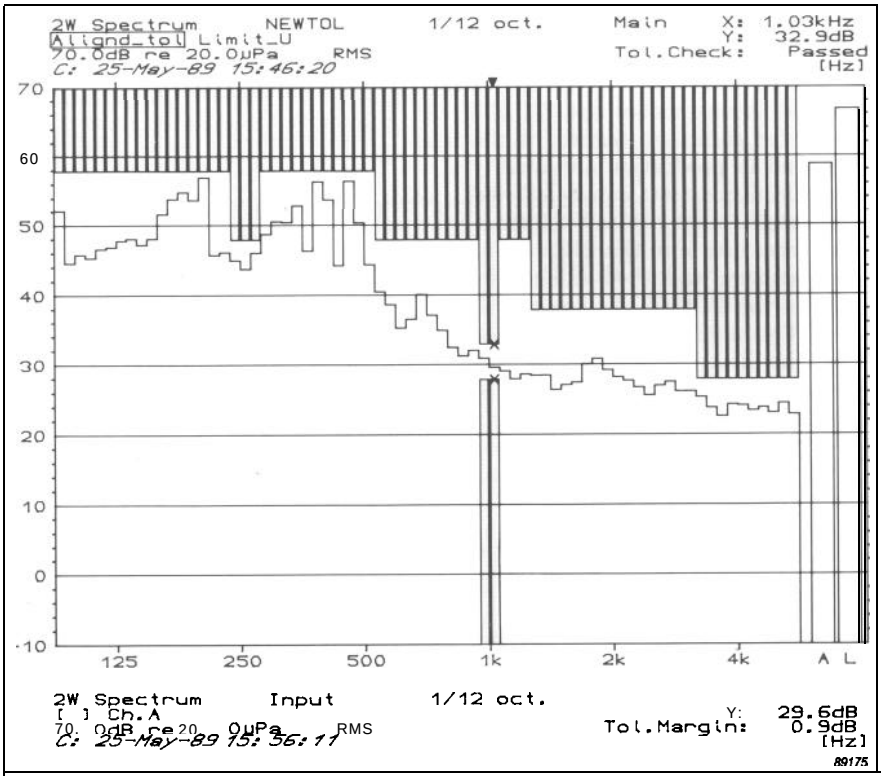

Fig. 5. Aligned tolerance testing in progress with 1/12 octave tolerances and the tolerance curves aligned to the test data at 1 kHz

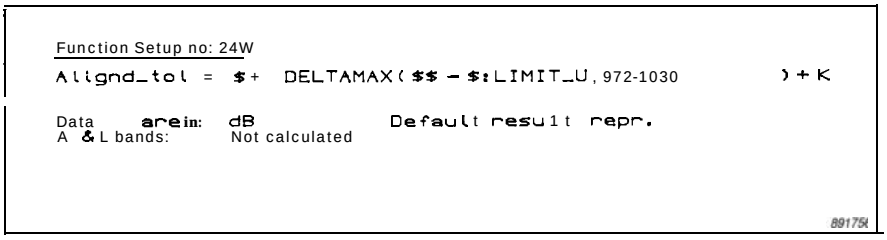

Fig. 6. The UDF used for the testing in Fig. 5, obtained by modifying pre-defined UDF No. 24

5. Floating Tolerance Testing

Floating tolerance testing is in some respects similar to aligned tolerance testing, in that the tolerance curves are moved up or down to try and match the test data. With floating tolerance testing, however, the 2123/33 attempts to fit the test data within the tolerance curves across the entire displayed frequency range, rather than just at one frequency. Floating tolerance testing is used where the overall frequency content of the test data is of importance rather than the absolute levels.

The 2123/33 contains a pre-defined UDF for floating tolerance testing, namely No. 29, Flting_Tol. It is used by calling it into the display containing the tolerance curves. Fig. 7 shows floating tolerance testing in progress with UDF No. 29 active. Where the test data is incoming measurement data, UDF No. 29 can be used directly. Where the test data is processed data, however, some modification of UDF No. 29 will usually be necessary.

6. Tolerance Testing on Slice Data

Although the description of tolerance testing given so far has been with respect to frequency domain data, it is equally applicable to slice data collected using the 2123133. Slice data plots the variation in level as a function of time or some other third parameter in a single frequency band collected using the 2123/33 in multispectrum mode, (for a description of use of the 2123/33 in multispectrum mode, see the Application Note, "Analysis of Transient and Non-stationary Signals using the Real-time Frequency Analyzers Types 2123 and 2133). Tolerance testing on slice data therefore allows testing of time-dependent data or data dependent on some other parameter, at a constant frequency.

Tolerance testing on slice data is identical to tolerance testing with spectral data, with the exception that slice data is used instead. Fig. 8 shows an example of tolerance curves formed around slice data.

7. Go/no- go Testing with the 2123/33

Tolerance testing makes the 2123/33 suitable for go/no-go testing of the type found in production and quality control. Multiple tests can be carried out by recalling the relevant tolerance curves from disc into the 2123/33 internal memory, and then calling the curves to the 2123/33 display as required. This avoids having to further access the disc, thereby saving the time involved, (the 2123/33 can hold many sets of tolerance curves in its memory at any one time). Such testing can be completely automated using autosequencing on the 2123133.

As an aid to automated testing, the pass/fail indication obtained through the auxiliary cursor read-out is available through the Remote Control Connector on the rear panel of the 2123/33. This gives a TTL true output when the auxiliary cursor read-out indicates pass, and can be used to drive other indication equipment, such as LEDs, lamps, etc. Further, where the 2123/33 is being autosequenced, tests can be repeated using the "Run/Stop" key, to give one button operation. The "Run/Stop" key can also be remotely accessed through the 2123/33 front panel remote control input.

8. Conclusions

The tolerance testing features described make the 2123/33 a powerful tool for go/no -go testing. They can be applied to both frequency and time domain data, allowing a broad range of test types. Further, through use of autosequences, such testing can be completely automated.

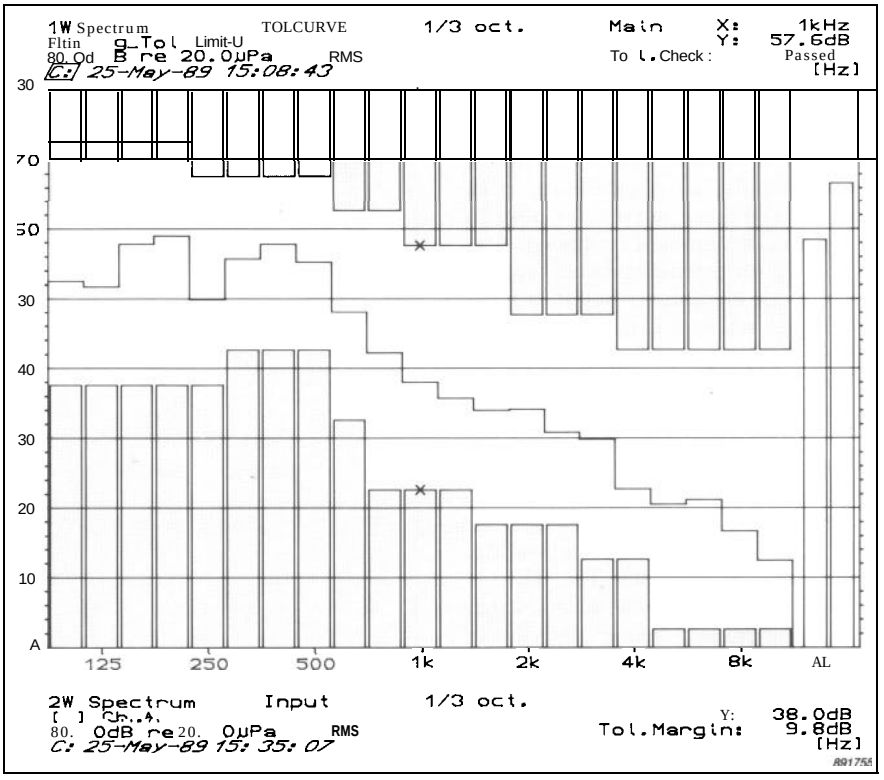

Fig. 7. Floating tolerance *testing* in progress *in* 1/3 *octaves*

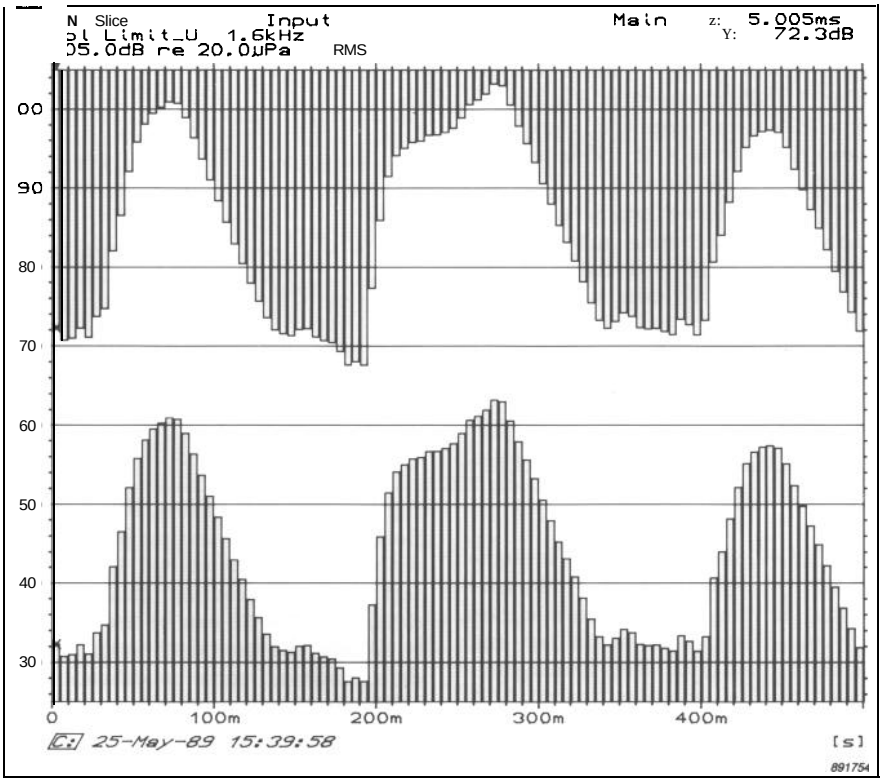

Fig. 8. Tolerance curves *formed around slice data*

Brüel & Kjær

WORLD HEADQUARTERS: DK-2850 Nærum Denmark. Telephone: +45 42 80 05 00 · Telex: 37316 bruka dk Fax: +45 42 80 14 05/+45 42 80 21 63

Australia (02) 450-2066 Austria 02235/7550*0 Belgium 02 242-97 45 Brazil (011) 246-8149/246-8166 Canada (514) 695-8225 Finland (90) 80 17044
France (1) 645720 10 Federal Republic of Germany 04106/70 95 0 Great Britain (01) 954-2366 Holland 03402.39994 Hong Kong 5-487486 Hungary (1) 33 83 05/33 89 29
Italy (02) 5244 141 Japan 03-438-0761 Republic of Korea (02) 554.0605 Norway 02-90 44 10 Portugal (1) 65 92 56/65 92 80 Singapore 2256533 Span (91) 266 1000
Sweden (08) 7112730 Switzerland (042) 65 11 61 Taiwan (02) 7139303 USA (508) 481-7000 Local representatives and service organisations world-wide

BO 0322-I 1

PRINTED IN DENMARK BY NÆRUM OFFSET