

# Audio system calibration using LabVIEW

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**Abstract** – In this paper audio system calibration with LabVIEW is given. The aim is to acquire, analyze and present audio data. It’s flexibility gives additional possibilities for custom audio measurements applications. Using LabVIEW software and hardware module enables the advantage of the personal computer processing power can be taken to perform complex signal analysis.

**Keywords** – LabVIEW, audio system calibration, ribbon microphone.

## I. ENABLES INTRODUCTION

Sound is very important for the satisfaction of the consumer using video system. Good surround sound audio contribute for increasing of video system quality. However this is one of the most difficult tasks. One require high-quality signal acquisition, acoustic anechoic chamber, extensive analysis, and graphical presentations.

The Number of devices which contain a microphone expands, therefore the test methods for audio devices are becoming more prevalent. The complexity of the devices continues to increase. This is the reason for the need of more complicated microphone calibration systems.

The flexibility of LabVIEW Virtual instrumentation gives additional possibilities for custom audio measurements applications. One is used to acquire, analyze and present audio data. This paper explains how audio system calibration in LabVIEW environment is made.

## II. AUDIO MEASUREMENT SYSTEMS ARCHITECTURE

Usually audio measurement systems begin with microphone for transducer that generates electrical signals according to the audio signals. To measure these electrical signals and input them to a computer for processing, data acquisition system is necessary. Dynamic signals such as audio signals require high-resolution and high-dynamic-range digitizing devices. NI LabVIEW software provides a dynamic signal acquisition hardware making it suitable for building audio calibration system. Thus, using software and hardware module, the advantage of the processing LabVIEW power of personal computer can be taken to perform complex signal

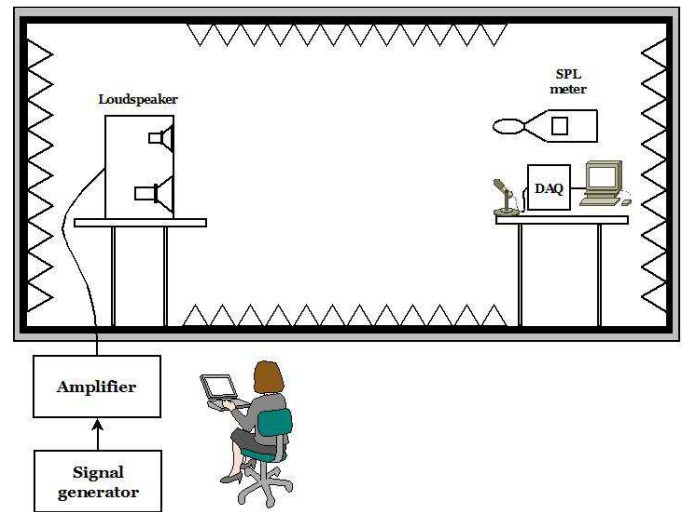


Fig. 1. The equipment used for audio system calibration using LabVIEW

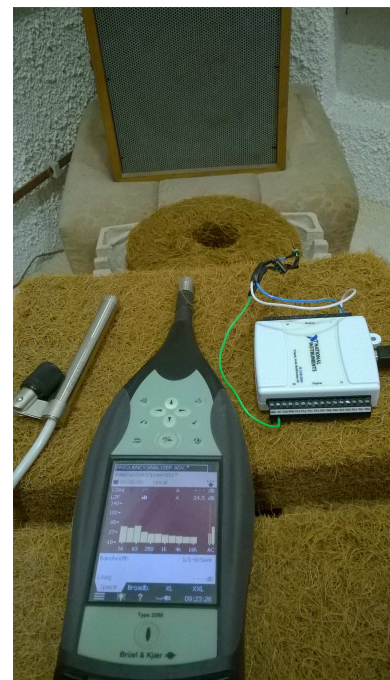


Fig. 2. Test setup

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analysis.

The equipment used for audio system calibration with LabVIEW is shown in figure 1. One includes signal generator, amplifier, loudspeaker, SPL meter, microphone, DAQ and computer. To obtain accurate results for the measurements acoustic anechoic chamber is needed. The test setup is shown in figure 2 and figure 3.



Fig. 3. Test setup

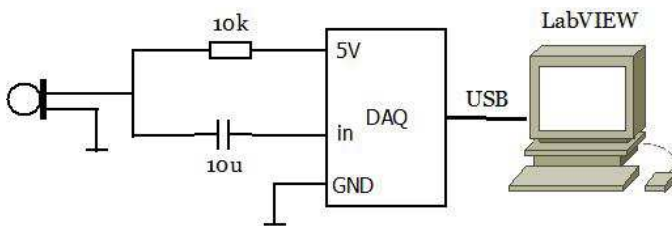


Fig. 4. Circuit design

Figure 4 presents a detailed circuit design for microphone calibration using LabVIEW data acquisition system and personal computer.

There have been made a series of measurements. The results are summarized. Based on these results correction factors for the microphone characteristic improving are proposed.

### III. AUDIO SYSTEM CALIBRATION

In order to be tested and calibrated a ribbon microphone the above described system is used. The ribbon microphone amplitude frequency characteristics is measured with the equipment, shown in figure 1. The results of the measurements that were made before the amplitude frequency characteristic equalization are given in Table 1. Based on these results relative correction factors for the microphone characteristic improving are proposed. The relative correction factors are denoted with CF1 to CF5 (figure 10).

After applying relative correction factors the measurements were made again. The ribbon microphone amplitude frequency characteristic is measured with the equipment

shown in figure 1, but in LabVIEW virtual instrument correction factors are added. These results are given in Table 2.

TABLE I  
MEASUREMENT RESULTS BEFORE CORRECTION

Frequency	Reference input level $R_I$	Power in Band $P_B$	Relative Correction factor $C_F$
20	68	-64	0,909090909
50	94	-38	0,909090909
100	94	-39	0,902255639
200	94	-38	0,909090909
300	94	-39	0,902255639
400	94	-40	0,895522388
500	92	-40	0,909090909
600	95	-37	0,909090909
800	92	-40	0,909090909
1000	95	-40	0,888888889
2000	93	-38	0,916030534
4000	90	-41	0,916030534
8000	92	-43	0,888888889
16000	87	-33	1
19500	88,4	-37,5	0,953137411
20000	87	-37	0,794701987

TABLE II  
MEASUREMENT RESULTS AFTER CORRECTION

Frequency	Reference input level $R_I$	Power in Band $P_B$	Measured level
20	94	-40	94
50	94	-39	95
100	94	-40	94
200	94	-40	94
300	94	-41	94
400	94	-40	94
500	94	-40	94
600	94	-40	94
800	94	-40	94
1000	94	-41	94
2000	94	-40	94
4000	94	-40	94
8000	94	-40	94
16000	94	-42	95
19500	88,4	-37,5	95
20000	87	-37	94

Correction factors and relative correction factors are calculated by equations (1) and (2) respectively.

$$K = R_l - P_B \quad (1)$$

$$C_F = \frac{K}{K_{16000Hz}} \quad (2)$$

Where K is the correction factor,  $R_l$  is the reference input level,  $P_B$  is the power in band,  $K_R$  is the relative correction factor and  $K_{16000Hz}$  is the correction factor for 16000 Hz frequency.

The LabVIEW block diagram is shown in figure 5. The LabVIEW version is 12.0f3. The data acquisition system input signals to the set of filters. For each frequency band a correction with the corresponding correction factor is made with aim to equalize the amplitude frequency characteristic. The next step is to perform octave analysis and spectral analysis to the obtained signal. Then virtual instrument *Power in Band* calculates the aggregate power in a specific frequency range which is determined by the user in VI settings. The LabVIEW front panel diagram is shown in figure 6. It includes the waveform graph, the signal spectral analysis and

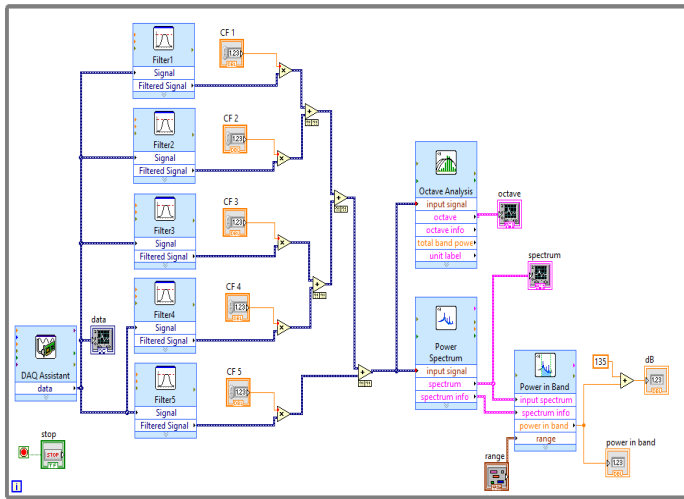


Fig. 5. LabVIEW block diagram

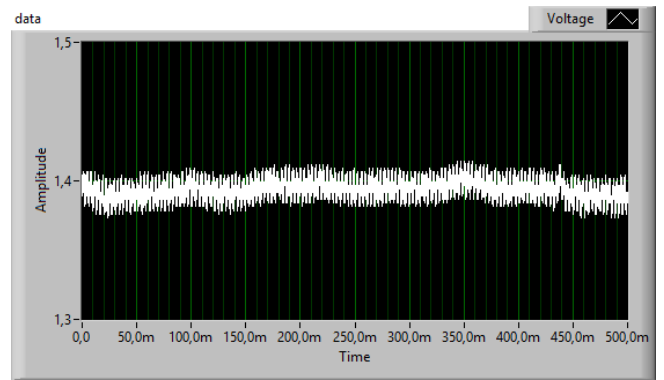


Fig. 7. Waveform graph

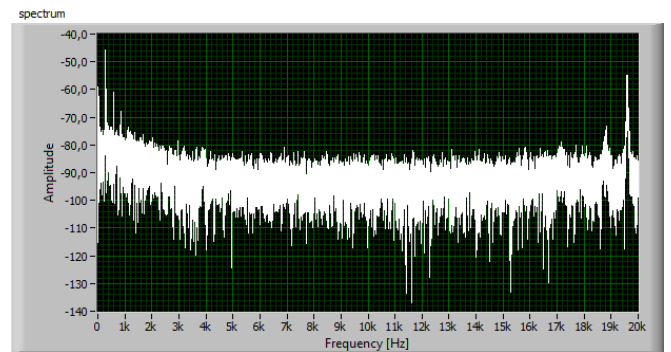


Fig. 8. Signal spectral analysis

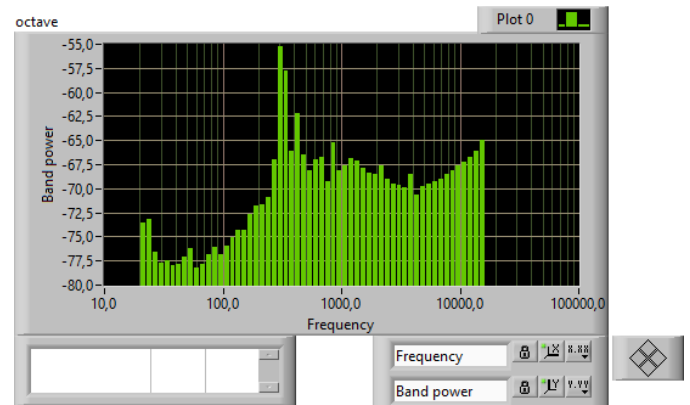


Fig. 9. Signal octave analysis

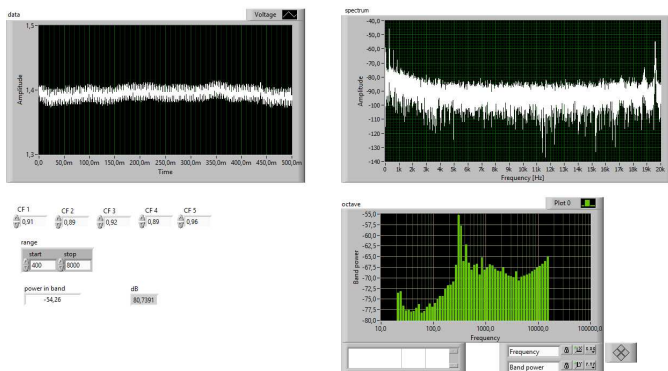


Fig. 6. LabVIEW front panel

octave analysis. For more detail presentation they are shown

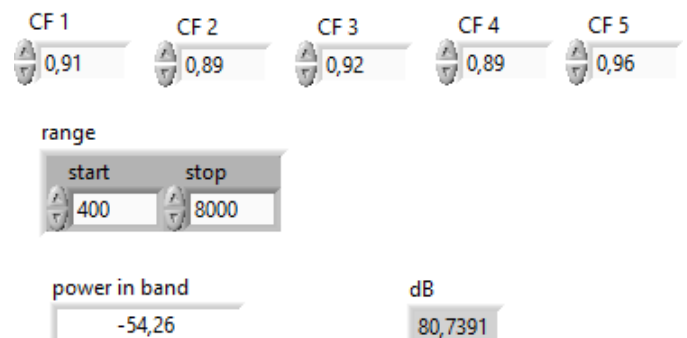


Fig. 10. The relative correction factors

separately in figures 7, 8 and 9.

The virtual instrument *Octave Analysis* exhibits characteristic analogous to the response of the human ear. This is the reason for widely use of this technique for analyzing audio and acoustical signals.

The error before and after microphone amplitude frequency characteristic correction is given in table 3. This error is depicted in Figure 11. It can be seen that after microphone amplitude frequency characteristic correction the error is reduced.

TABLE III  
ERROR CALCULATION BEFORE AND AFTER MICROPHONE AMPLITUDE FREQUENCY CHARACTERISTIC CORRECTION

Frequency	$\delta_1$	$\delta_2$
20	2,941176	0
50	2,12766	1,06383
100	1,06383	0
200	2,12766	0
300	1,06383	-1,06383
400	0	0
500	2,173913	0
600	2,105263	0
800	2,173913	0
1000	-1,05263	-1,06383
2000	3,225806	0
4000	3,333333	0
8000	-1,08696	0
16000	16,09195	-2,12766
19500	9,162896	-2,12766
20000	-19,5402	0

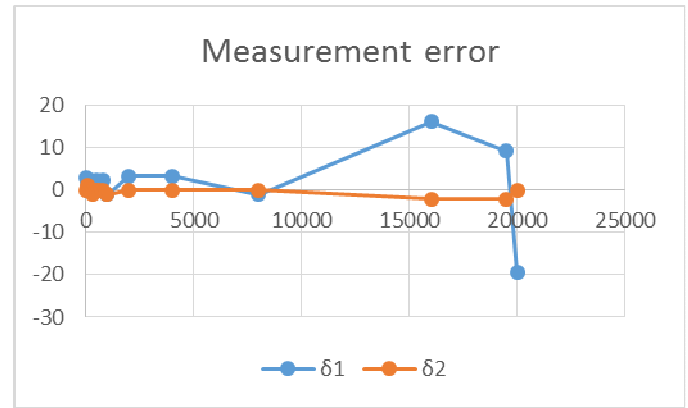


Fig. 11 Illustration of Error before (blue) and after (red) microphone amplitude frequency characteristics correction

#### IV. CONCLUSION

In this paper a microphone calibration in LabVIEW environment is made. The ribbon microphone amplitude frequency characteristic is measured. There have been made a series of measurements. The results are summarized. Based on these results, correction factors for the microphone characteristic improvement are proposed. It is realized multipoint calibration microphone amplitude frequency characteristic by using LabVIEW. On this way error decreasing is achieved. After applying correction factors the measurements were made again. The included in the paper tables and figures illustrate the microphone amplitude frequency characteristic improvement.

#### REFERENCES

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