Averaging of 1/n Octave Spectra
Application Note

Products:

| R&S®UPV

| R&S®UPV-K1

| R&S®UPV-K6

This document describes an application program for averaging 1/n octave spectra on the R&S® Audio Analyzer UPV.

ROHDE&SCHWARZ

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Background

1/n Octave Spectra

While spectral transforms like FFT provide constant absolute bandwidth (i.e. the bins are equally spaced in terms of Hz), 1/n octave analysis provides an analysis bandwidth which is proportional to the centre of each band throughout the analyzed frequency range. This is called constant relative bandwidth.

In acoustic frequency analysis constant relative bandwidth is quite common, mainly because human hearing acts this way for frequencies above 500 Hz. Due to this reason also musical intervals are based on frequency relations rather than absolute frequency differences. A prominent musical interval is the so-called octave which represents a frequency ratio of 2:1. In musical score, notes which are one octave apart are perceived as functionally similar and are therefore assigned similar names (e.g. c' and c''). Other common musical intervals are major thirds (frequency ratio of $f_2/f_1 = 5/4 = 1.25$ which is roughly the same as 1/3 octave, $f_2/f_1 = \sqrt[3]{2} \approx 1.26$) and half-tone (1/12 octave, $f_2/f_1 = \sqrt[12]{2} \approx 1.06$).

In audio frequency analysis octaves, 3rd octaves and subdivisions of 3rd octaves (mainly 12th and 24th octaves) are common frequency resolution values.

Center frequencies of 3rd octaves and their subdivisions can be based on a row of frequencies with ratio $\sqrt[3]{2} \approx 1.2599$ or with ratio $\sqrt[10]{10} \approx 1.2589$. The latter is often preferred because the values 10, 100, 1000 etc. are exactly met this way. These center frequency values can e.g. be taken from R.10 series (3rd octaves), R.40 series (1/12 octaves) and R.80 series (1/24 octaves) of ISO 3.

Frequency dependent attenuation of octave and fractional octave filters is standardized in IEC 61260.

1/n Octave Analysis on the R&S® Audio Analyzer UPV

For details of the analyzer function "1/n Octave" see the UPV user manual.

This analysis function provides the measurement modes Octave, 1/3 Octave, 1/6 Octave, 1/12 Octave, 1/24 Octave and Critical bands. "Critical bands" uses a 1/3 Octave bandwidth above 500 Hz and a constant bandwidth of 100 Hz below 500 Hz. This represents the typical frequency dependent resolution bandwidth of the human ear.

The user has to specify a lower band limit for the analysis in field "Frq Lim Low" and an upper band limit in field "Frq Lim Upp".

The "1/n Octave" analysis function of the R&S® Audio Analyzer UPV first performs a FFT of the input signal and then calculates the level in each 1/n octave band by summing up the energy in the FFT bins falling within the 1/n octave band in question. The FFT size is automatically selected according to the frequency resolution required for the lower band limit specified in the "Frq Lim Low" field.

If "Meas Time" is set to "Auto", the acquisition time equals the length of one FFT of the suitable size chosen by the analyzer. If "Meas Time" is set to "Value" and a numeric value is entered, this entered value is automatically rounded up to the closest integer multiple of the chosen FFT length. The resulting spectrum is equal to a rms average of the spectrum over the whole measurement time.

The resulting spectrum can be displayed in one of the two bargraph displays. The function result of the "1/n Octave" analyzer function displayed in the numeric display is the rms sum of all analyzed bands.

Averaging

The influence of one value contributing to an average depends on the unit in which the numbers are averaged. When power values are averaged (e.g. rms averaging of voltage values), higher values have a higher influence on the average result than with linear averaging of voltages. When levels (dB values) are averaged, one higher values have the least influence on the average compared to lower values.

Single values $V_1 \dots V_n$

Linear Average
$$\overline{V} = \frac{1}{n} \sum_{i=1}^{n} V_i$$

RMS Average
$$\overline{V} = \sqrt{\frac{1}{n} \sum_{i=1}^{n} V_i^2}$$

Averaging of dB Values
$$\overline{V} = 10^{\left(\frac{1}{20*n} \sum_{i=1}^{n} 20*\log_{10}(V_i)\right)}$$

Example1:
Single values: 1 V, 1 V, 1V, 1 V, 2 V
Linear average: 1.2 V
RMS Average: 1.265 V
Averaging of dB values: 1.148 V

Example2:
Single values: 1 V, 1 V, 1V, 1 V, 0.5 V
Linear average: 0.9 V
RMS Average: 0.922 V
Averaging of dB values: 0.871 V

Installing the Application Software

Prerequisites

The use of the 1/n octave analysis requires option UPV-K6 (extended analysis functions). The use of the application program provided with this application note requires option UPV-K1 (universal sequence controller). For modification of the supplied source code of the application program the VB.Net IDE (integrated development environment) provided with option UPV-K1 must be installed. The VB.NET IDE is not required for installing and running the program from the installer.

Required files

Copy "1GA52.msi" to the UPV hard disk, e.g. to "D:\R&S Software\Application Notes". Unzip "1GA52_setups.zip" and copy the setup files to "D:\UPV\Setups" on the UPV hard disk.

Installation

Run installation file "1GA52.msi" from the UPV hard disk and follow the instructions on the screen. The installer creates a shortcut on the desktop and in "Programs" within the start menu.

Using the Application Software

General Remarks on the Functionality

The application program collects 1/n octave spectra from bargraph1 of the UPV window, calculates an average over a specified number of subsequent spectra and writes the resulting average spectrum back to bargraph2. In addition the total rms summed up over the averaged spectrum is displayed in a numeric field.

The application program assumes a setup to be loaded to the UPV in which the analyzer function and bargraph1 are set according to the user requirements. Two sample setups are provided in "1GA52_setups.zip" for download with this application note. The setups may be modified according to the user's needs.

The application program copies the scaling of bargraph1 to bargraph2. Furthermore it detects whether one or two analyzer channels are in use. If only one analyzer channel is required, channel 1 must be used. The use of channel 2 alone is not supported. To switch to two-channel measurement, "Channel" in the analyzer config panel must be set to "2 = 1" or "1 & 2", and "Y-Source" of trace B must be set to "Funct Ch2" in the Bargraph1 config panel. Bargraph2 will be configured automatically by the application program.

The function result shown in the numeric field of the application program window is always the RMS sum of the total spectrum. However it is displayed in the unit specified for the spectrum in the loaded setup.

The application program can be run continuously providing a sliding average over the last n spectra, updated for each new spectrum. Alternatively only the specified number of spectra can be measured and averaged.

The application program activates the continuous update for the UPV window which is par default frozen during remote control. This corresponds to the activation of the "SCPI Update" checkbox in the config panel. Do not attempt to control the UPV firmware while the application program is running!

To use a cursor in Bargraph 2, make sure that "Movement" is set to "Next Value" for the respective cursor in the softkey menu.
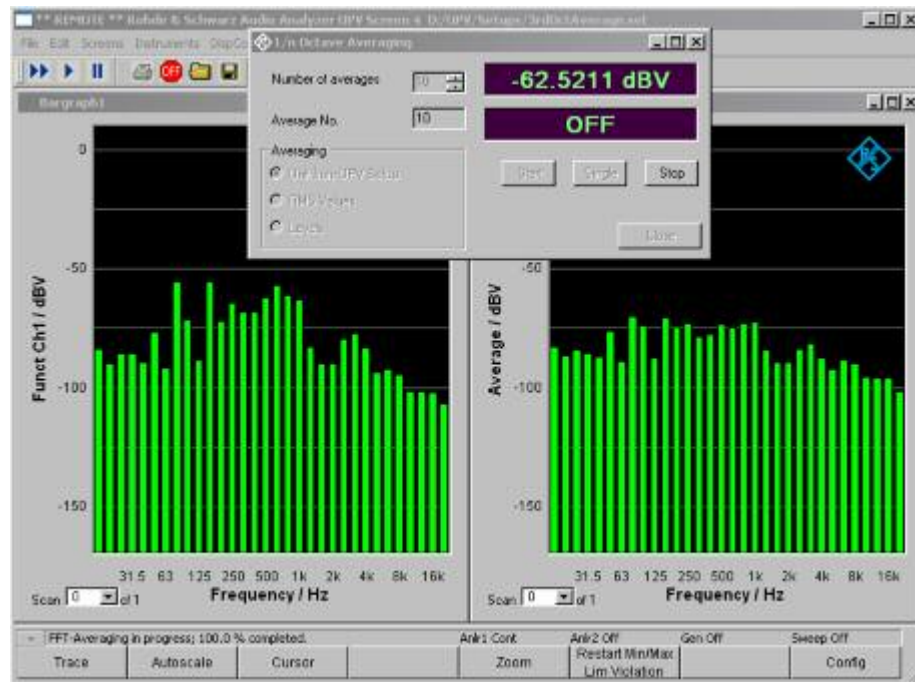
User Interface

Figure 1: Example setup with superimposed user interface of the application program

- "Number of averages" specifies the number of spectra to be averaged. Minimum is 1 and maximum is 100.
- "Average No." shows the number of spectra collected. The average is only displayed when the specified number of spectra has been collected.
- Averaging specifies the type of unit in which the values are averaged.
  - "Unit from UPV Setup" averages the numbers read from bargraph1 in the unit set in bargraph1. If "dBV" is set, dB values are averaged, is "V" is set, voltages are averaged and if "W" is set, power is averaged.
  - "RMS Values" always does an RMS average, even if a dB unit or power unit is set in bargraph1.
  - "Levels" always averages dB values irrespective of the unit set in bargraph one. However, the average is converted back to the unit set in bargraph1 before writing it to bargraph2.
- The numeric fields show the RMS sum over the whole spectrum for the active channel(s).
- The "Start" button starts a continuous measurement with sliding average. The resulting average spectrum and numeric value are continuously updated as soon as at least the specified number of spectra to be averaged has been acquired.
- The "Stop" button stops a running continuous measurement.
- "Single" causes the specified number of spectra to be collected, averaged and written back to bargraph2. After that the acquisition stops automatically.
- "Close" ends the application program and closes the control window.

Working with the Source Code

- Download "1GA52_VB2003.zip", "1GA52_VB2005.zip" or "1GA52_VB2008.zip" according to the version of the VB.Net IDE installed on the UPV
- Unzip the file to the VB.Net projects folder on the UPV hard disk
- Open file "NthOctaveAverage.sln" from the VB.Net IDE

Literature

- R&S$^®$ UPV User Manual
  http://www2.rohde-schwarz.com/en/products/test_and_measurement/audio/UPV-|-Manuals-|-22-|-2224-|-2234.html
- ISO 3 "Preferred numbers -- Series of preferred numbers"
  http://www.iso.org/iso/catalogue_detail.htm?csnumber=3564
- IEC 61260 "Electroacoustics - Octave-Band and Fractional-Octave-Band Filters"
  http://webstore.iec.ch/webstore/webstore.nsf/artnum/024824

Ordering Information

Ordering Information		
Type of instrument		
Description	**Instrument type**	**Ordering number**
Audio Analyzer	R&S$^®$UPV or	1146.2003.02
	R&S$^®$UPV66	1146.2003.66
Extended analysis functions	R&S$^®$UPV-K6	1401.9201.02
Universal sequence controller	R&S$^®$UPV-K1	1401.7009.02

About Rohde & Schwarz

Rohde & Schwarz is an independent group of companies specializing in electronics. It is a leading supplier of solutions in the fields of test and measurement, broadcasting, radiomonitoring and radiolocation, as well as secure communications. Established 75 years ago, Rohde & Schwarz has a global presence and a dedicated service network in over 70 countries. Company headquarters are in Munich, Germany.

Environmental commitment
- Energy-efficient products
- Continuous improvement in environmental sustainability
- ISO 14001-certified environmental management system

Certified Quality System
ISO 9001

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