NTI RT-2M
FAST MULTITONE AUDIO ANALYZER WITH RUB&BUZZ TESTER

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Multitone Testing

Production testing of loudspeakers – either drivers or systems – presents a number of choices. First, what shall we measure? Certainly the most common parameter to measure is frequency response, but this measurement alone provides much more data about the speaker's design than its manufactured quality. Provided that the driver components are properly QC'ed, the most common production faults in speakers tend to produce more distortion rather than significant frequency response anomalies.

But what kind of distortion? Czerwinski, *et al* presented two excellent papers to the AES 109th convention (November 2000) on the topic of measuring nonlinear distortion.[1] Their conclusions, which agree with those of other careful researchers, indicate that **traditional THD testing is useless** in that it does not correlate with annoyance. Further, traditional 2-tone or 3-tone IM testing is not much better. Referencing previous authors, they propose the use of a multitone signal and an analyzer capable of identifying IM distortion of various orders. Not only does such a signal more nearly approximate the complexity of a musical waveform, but it provides a much more rapid means of testing than does any sort of a swept-signal test.

Photo 1: The NTI Rapid Test RT-2M Fast Multitone Audio Analyzer

Instrument Capabilities

The NTI RT-2M Fast Multitone Audio Analyzer (Photo 1), used in concert with a decent PC, offers the capability of programmable multitone signal generation and measurement analysis in a single-rack-space package. The RT-2M contains two independent multitone arbitrary waveform generators utilizing a 48 kHz sampling rate. The bandwidth is 20 to 20,000 Hz. Block lengths of 512, 1024, 2048, 4096, and 8192 are provided, permitting a frequency resolution of 5.86 Hz. Residual distortion is specified at -86 dB or 10 µV. Both flatness and level accuracy are 0.2 dB. There are four stereo signal memories for storing arbitrary signals that the user has created, and each signal can contain from 1 to 31 frequencies. The output level is adjustable in 0.1-dB steps from -60 to +29 dBVp, and output impedance can be set at 150 or 600 ohms.

The analyzer is also a 2-channel unit, and it provides measurement of level, total distortion, RSS selective level, noise, interchannel phase, crosstalk, multitone SINAD, return loss, echo return loss, frequency, and DTMF analysis. Sampling rate is 48 kHz, and bandwidth is 20 to 20,000 Hz, with >90 dB dynamic range. Frequency resolution for multitone amplitude measurements is 2.95 Hz, and for frequency measurements, it is 0.025 Hz. Flatness and level accuracy are specified at 0.2 dB. Input impedances are selectable to 600 ohms or 100 kohm. Input signals from -60 to +40 dBVp can be handled. Phantom power is provided for measurement microphones, as is an input adapter to convert from the back-panel banana jacks to XLR connectors for use with the optional 1/4" or 1/2" measuring microphones.

You can connect the instrument to the computer through either RS-232 or National Instruments GPIB ports; of course the latter provides for faster throughput. The RT-2M instruction manual provides an excellent description of the operation and application of the instrument, including programming commands. Although this review focuses on rub and buzz testing with the RT-2M (which is an option), the basic instrument can well find a place in production testing of many audio electronic and electroacoustical devices.

Rub & Buzz Testing

Previously, I mentioned that common production defects in loudspeakers tend to produce distortion – specifically, buzzes. Mis-centered, cocked, or out-of-round voice coils, foreign matter (or even domestic matter) in the gaps, faulty glue joints, slit or torn cones or spiders, improper lead-wire dress, and more, can cause these buzzes.

The traditional test instrument for such distortion is a calibrated human. The disadvantages of this instrument – ongoing costs, the need to rotate testers to compensate for auditory fatigue – have for many years been outweighed by the advantage: human testers can easily detect distortion that will annoy humans. And the lack of this ability is what has hampered the development of successful electronic rub and buzz testers in the past.

The problem is threefold. First the tester must be able to distinguish between ordinary levels and types of distortion that a listener would tolerate and abnormal levels and types of distortion (that cause annoyance). This depends upon whether the distortion is primarily harmonic or inharmonic and the frequency range in which it occurs, as well as its level relative to the desired signal. Second, the tester must have very fine frequency resolution, since some buzzes in speakers result from very high-Q resonances. Third, the cycle time for the tester must be as short as possible, for economic reasons.

Several attempts have been made in the past to develop test instruments meeting these requirements, but none has met with unqualified success. Often, the problem has been that the instrument could not be calibrated to reject defective units without rejecting far to many acceptable units also. In part, this was the result of the inherent conflict between distortion measurement and cycle time: measurement with fine frequency resolution requires a long cycle time.

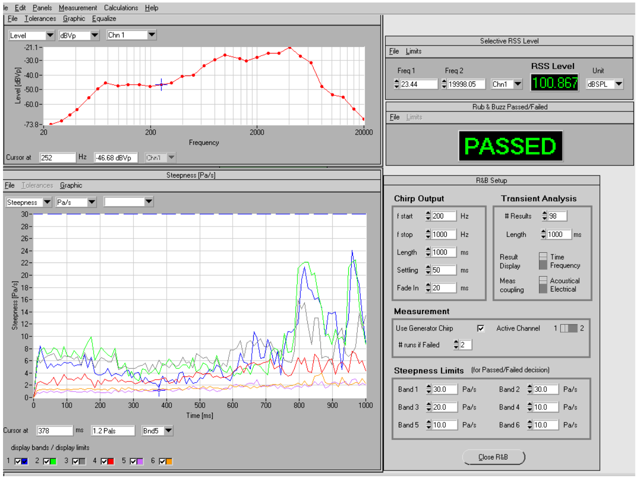

Figure 1: NTI Rub&Buzz test results - ‘normal speaker’

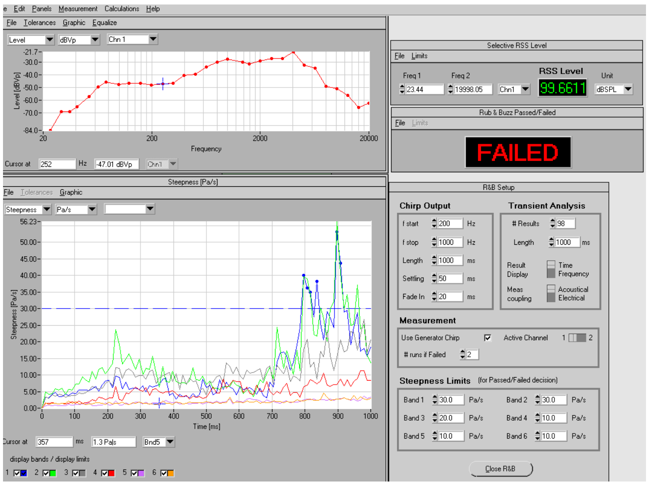

Figure 2: NTI Rub&Buzz test results - speaker with poor leadwire dress

The NTI Solution to Rub and Buzz Testing

The approach to rub and buzz testing that is employed in the RT-2M was developed by Leonhard Research A/S, of Denmark. It utilizes a continuous (not stepped) swept tone and analyzes the steepness of the waveform reproduced by the speaker. Since the sweep contains no frequencies higher than 1500 Hz, it can predict the maximum slope of the undistorted waveform. Distortion produces higher frequencies with waveforms of correspondingly faster slopes. It is much faster to analyze a sweep waveform for its slope than to perform an FFT on it to detect extraneous frequencies.

After the waveform is analyzed for 'steepness', the result is split into what are effectively frequency bands, corresponding to different regions of the audible spectrum. The steepness is then plotted in a different color for each band, versus either time or frequency. (Since the sweep is linear, time is easily converted to or from frequency.) The RSS sound pressure level is also displayed on the screen. If the steepness exceeds the preset maximum value for any band, the word **FAILED** appears on the computer screen in large unfriendly, red letters.

Since impulsive ambient noise can cause erroneous steepness readings, you can set the software to repeat a measurement whenever a speaker fails the rub/buzz test. If the band in which the failure occurred passes on the second or later test, the previous high reading is assumed to result from noise, and the speaker is passed. The user can set the number of automatic retests.

Setting up the rub and buzz application is quick: once the RT-2M is connected to the computer and the software is loaded, setup takes only about five minutes. Once setup is complete, the user simply clicks on a **GO** button on the computer screen, and the multitone and rub&buzz test are performed automatically. Depending upon the transient analysis length selected, the test can be completed and results displayed in less than a second. Worst-case would be under two seconds.

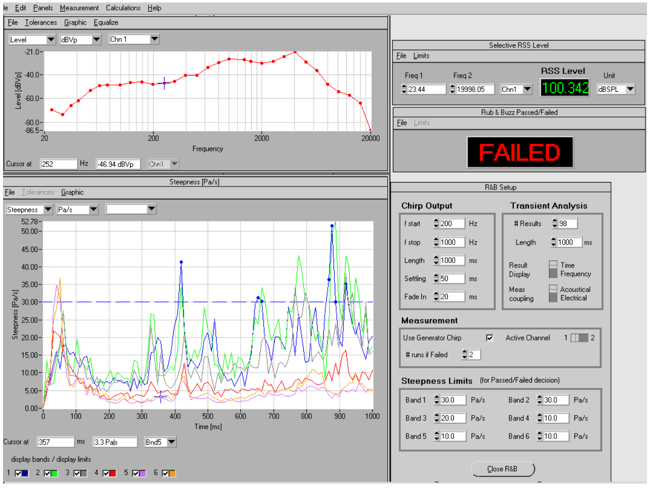

Figure 3: NTI Rub&Buzz test results - speaker with voice-coil rub

Figure 4: NTI Rub&Buzz test results - speaker with torn cone

Some experimenting is required in order to find the correct limits for each band. Such variables as cone material, edge damping, voice coil overhang, and basket thickness/damping can affect the “normal” steepness of a particular speaker design. So in setting up the RT-2M for automated operation, a selection of known good speakers should be tested, and you should adjust the steepness limits on the R&B Setup panel (on the computer screen) to exceed these normal values.
You can then fine-tune the settings by checking rejects to determine just how high the steepness in each band must be to exceed the usable range. In initial tests with a variety of types of good speakers, I encountered steepness ranges from 5.8 up to about 25 Pa/s. (Steepness is stated in acoustical terms, as you probably just noticed.)

Figures 1 through 4 show the results of testing four speakers of identical design. Figure 1 shows the “normal” or reference speaker. Notice that the steepness of three of the bands is above 10 Pa/s. Maximum steepness is 24 Pa/s. The speaker under test is an electronic organ speaker with a paper cone having no edge damping applied. I suspect that the undamped edge produces extraneous frequencies that result in high steepness readings.

Figure 2 shows the results of testing a speaker with poor lead-wire dress: the tinsel wires were contacting the cone at one place. Maximum steepness is 56 Pa/s.

Figure 3 shows test results for a speaker having a voice-coil rub. Maximum steepness is 34 Pa/s.

Figure 4 shows test results for a speaker with a torn cone. Maximum steepness is 53 Pa/s

If you compare the steepness curves of Figures 1 through 4, you will see that not only the steepness varies among the different speakers. Each defect produces a specific signature in terms of the time at which the maximum steepness occurred (*i.e.*, the frequency that triggered the maximum effect), and the band in which it occurred (*i.e.*, the extraneous frequencies produced). You can use this information to determine the cause of the failure for quality-control and rework purposes.

Just for information, I also performed multitone SINAD tests on the four speakers; Table 1 shows the results.

Table 1: SINAD Measurements on the four Speakers

Speaker	SINAD (dB)
1	-35.63
2	-26.93
3	-33.7
4	-34.3

Notice that the voice-coil rub and the torn cone caused less than 2 dB difference in SINAD, whereas they caused large increases in steepness. These results illustrate the relative insensitivity of traditional distortion measurements to such defects. The steepness results gave a clear indication of the problems. In fact, the steepness measurements gave as clear an indication of the defects as did the sound of the speakers.

Comments on the System

I found the RT-2M to be an excellently engineered and user-friendly piece of test equipment. I had only two problems with the software. The "Basic Speaker Test Application" that one must load into the computer's RT-2M control panel caused the display parameters of the computer to change. Specifically, the resulting display is stretched horizontally so that the scroll bar disappears off the right-hand side of the screen. Since the buttons in the upper right-hand corner also disappear, the only way one can work with the program is to change the computer's display settings through the Windows Control Panel, using a higher screen resolution. This problem is present no matter what resolution is used initially, so that it would be well not to start the computer display set for maximum resolution!

The other problem is that although the evaluation software ("RT-Eval") allows one to print a screen, there is no provision for saving a bitmap or other graphic file so that one could incorporate screens from the software in reports, training manuals, etc. The figures in this article were gathered via Paintshop Pro screen captures.

If the user writes his/her own application software for the RT-2M, these items would be avoided.

In summary, the NTI RT-2M is an excellent test instrument, and in particular, its rub & buzz test software, called 'PureSound' are well worth considering for production speaker testing.

Additionally (not part of product review in VoiceCoil magazine):

NTI offers additionally

- **ready to go, simple to operate production software, called 'RT-Speaker'**
- **frequency response & impedance measurement up to resolutions of 500 points**

Reference

1.Czerwinski, Eugene, et al; "Multitone Testing of Sound System Components – Some Results and Conclusions"; JAES 49, 11 (November 2001) and 12 (December 2001).

Manufacturer Response

- Regarding screen size/resolution, you are right - the choice of this high screen resolution was not a particularly good idea. However, there's no need to change the screen resolution in the windows settings. Since the title bar of the RTEval window is always visible, simply drag the window until a corner of it becomes visible, and scale the window to the appropriate size. Scale the measurement windows inside the window to the appropriate size and arrange them to your needs, and then choose 'Save application' from the file menu and overwrite the original application file.

- Regarding bitmap file generation, you are also right - it's currently not possible to produce a bitmap file of the whole RTEval application. We'll implement this in the next release of RTEval. However, please note that you can produce bitmap files from any graphical measurement panel (level, steepness, and so on). You will find this in the 'File ->Create Bitmap File' menu of the measurement panel.

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