Listening Room Acoustic Measurement Techniques
Test CD 1

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Test CD version 1.0

Notes:
a. Noise bands: 15 pole Chebyshev filter slopes
b. Modulated tones: +-5% deviation, 5Hz modulation rate

Track	*Contents*
1	Pink noise, 120 seconds
2	White noise, 120 seconds
3	Pink noise 20Hz – 40Hz band
4	Pink noise 40Hz – 80Hz band
5	Pink noise 80Hz – 160Hz band
6	Pink noise 160Hz – 320Hz band
7	Pink noise 320Hz – 640Hz band
8	Pink noise 640Hz – 1280Hz band
9	Pink noise 1280Hz – 2560Hz band
10	Pink noise 2560Hz – 5120Hz band
11	Pink noise 5120Hz – 10240Hz band
12	Frequency modulated sine wave test tone, -6dB level, 20Hz
13	Frequency modulated sine wave test tone, -6dB level, 25Hz
14	Frequency modulated sine wave test tone, -6dB level, 32Hz
15	Frequency modulated sine wave test tone, -6dB level, 40Hz
16	Frequency modulated sine wave test tone, -6dB level, 50Hz
17	Frequency modulated sine wave test tone, -6dB level, 63Hz
18	Frequency modulated sine wave test tone, -6dB level, 80Hz
19	Frequency modulated sine wave test tone, -6dB level, 101Hz
20	Frequency modulated sine wave test tone, -6dB level, 127Hz
21	Frequency modulated sine wave test tone, -6dB level, 160Hz
22	Frequency modulated sine wave test tone, -6dB level, 200Hz
23	Frequency modulated sine wave test tone, -6dB level, 254Hz
24	Frequency modulated sine wave test tone, -6dB level, 320Hz
25	Frequency modulated sine wave test tone, -6dB level, 400Hz
26	Frequency modulated sine wave test tone, -6dB level, 508Hz
27	Frequency modulated sine wave test tone, -6dB level, 640Hz
28	Frequency modulated sine wave test tone, -6dB level, 806Hz
29	Frequency modulated sine wave test tone, -6dB level, 1000Hz
30	Frequency modulated sine wave test tone, -6dB level, 1270Hz
31	Frequency modulated sine wave test tone, -6dB level, 1600Hz

Track	***Contents***
32	Frequency modulated sine wave test tone, -6dB level, 2000Hz
33	Frequency modulated sine wave test tone, -6dB level, 2540Hz
34	Frequency modulated sine wave test tone, -6dB level, 3200Hz
35	Frequency modulated sine wave test tone, -6dB level, 4000Hz
36	Frequency modulated sine wave test tone, -6dB level, 5000Hz
37	Frequency modulated sine wave test tone, -6dB level, 6400Hz
38	Frequency modulated sine wave test tone, -6dB level, 8000Hz
39	Frequency modulated sine wave test tone, -6dB level, 10k24Hz
40	Frequency modulated sine wave test tone, -6dB level, 12k9Hz
41	Frequency modulated sine wave test tone, -6dB level, 16k25Hz
42	Low frequency slow sweep, 20Hz – 160Hz
43	2 second tone burst, -6dB level + 8 seconds silence, 125Hz
44	2 second tone burst, -6dB level + 8 seconds silence, 250Hz
45	2 second tone burst, -6dB level + 8 seconds silence, 500Hz
46	2 second tone burst, -6dB level + 8 seconds silence, 1kHz
47	2 second tone burst, -6dB level + 8 seconds silence, 2kHz
48	2 second tone burst, -6dB level + 8 seconds silence, 4kHz
49	3 cycle tone burst, -6dB level, 5 seconds silence, 250Hz
50	3 cycle tone burst, -6dB level, 5 seconds silence, 500Hz
51	3 cycle tone burst, -6dB level, 5 seconds silence, 1kHz
52	6 cycle tone burst, -6dB level, 5 seconds silence, 2kHz
53	0dB level, 1kHz, 10 second duration
54	10 seconds silence

Application Details

Equipment Required

1. Marshall Choong Test CD 1
2. Modified Radio Shack analogue sound level meter model 33-4050
3. A camera tripod is suggested to support the meter but this is not necessary.

TEST 1 Speaker Response Testing

Procedure

1. Set up the signal source to CD and set your initial system volume setting relatively low i.e. around 10% of maximum.

2. Turn on the sound level meter and set it to the 70dB range, 'C weighting' (flat) and 'SLOW' response.

3. Select track 25 (modulated 400Hz), set the cd player to 'repeat 1 track' mode, and play through one channel only.

4. Place the sound meter at 1 meter from the speaker, in line with the mid range unit or tweeter and adjust the amplifier volume level to give 0dB on the sound meter. This is your reference level.

   Note at this distance the speaker output will tend to dominate the measurements. At 1.5m and greater the room reverberant field will dominate except with speakers with a directional high frequency response. (See www.audiophilerecordingstrust.org.uk for more detailed articles on room effects).

5. Step through the required test tones, which are tracks 12 – 41 (20 – 16kHz), and note the average sound meter reading for each test tone. Do not be surprised if you do not hear much until you get to track 14 or 15 (32 and 40Hz), not many speakers will reproduce 20, 25 and even 32Hz without serious loss !

6. Plot the results directly on the response graph available for download on the Audiophile Recordings Trust website. Plot 1 shown in the appendix at the end of the article is of a simple 2 way speaker with a comparison using a Real Time Analyzer and pink noise. Good agreement is seen over most of the frequency range but with slightly more sensitivity to room mode effects below 100Hz using the test tones.

7. You may repeat the exercise at your normal listening position of 1.5 – 2m to see the effect of the room or at an even closer 'near field' position of 0.5m which will further reduce the effect of the room.

8. The full octave pink noise signals may also be tried. This signal gives a wider average both in the time and frequency domains and is a quick and easy test of the overall balance of the system over the audio spectrum.

TEST 2 Evaluating Room Effects On Speaker Response

Room gain effect are most apparent in rooms with heavy solid boundaries i.e. brick walls, 2 bricks thick. Little low frequency absorption takes place and standing waves and higher bass response levels occur below 100Hz in corner positions. More flexible walls such as plaster board / wood frames tend to absorb some of the bass energy or transmit it to the next room. Most rooms will be somewhere in between the 2 extremes.

The procedure here is the same as doing test 1 but at 2 specific distances and a number of locations in the room.

1. Carry out TEST 1 at 0.7m measurement distance which is your 'near field' measurement set. This will give you a reference for the next measurement set.

2. Repeat at your normal listening position which will probably be at 2m.

3. Plot both sets of results.

Room Gain Effects

If your speakers are capable of giving a good response at 50Hz i.e. around 3dB or less loss, most rooms will boost the frequencies below 100Hz by about 6dB thus making the bass sound too noticeable in full range recordings. Marshall Choong produce a simple passive filter working at pre-amp levels which can be used to improve the accuracy of the bass response.

Room Absorption Effects

More complicated distortions of speaker responses will take place in rooms treated with absorptive materials.

These will depend on HF driver characteristics and types e.g. dome, ribbon, planar and the types and extent of any advanced audio room treatment.

See www.audiophilerecordingstrust.org.uk for more detailed articles on room effects and audio room treatment.

Other Test Signals on the CD

The remaining signals are for more advanced tests using a pc / laptop equipped with a sound recording program. See below.

The sound meter is equipped with an ac output which can be directly connected to a pc sound card.

2 Second Tone Bursts

These signals are for testing the rise and fall time of the room which is controlled by its reverberation time. See the section on this topic below.

3 Cycle Tone Bursts

These may be used to observe unwanted multiple reflections in the room.

0dB level 1kHz signal and Silence signal level

This is provided to check the minimum and maximum cd signal levels through the system. ***The 0 dB level is not intended to be played back at full listening level as this may damage some speakers.***

Pink and White Noise signals

These are convenient sources of full audio bandwidth random signals for full range testing with Real Time Analyzers.

Room Transient and Reverberation Time measurements

Users with access to a pc equipped with a reasonable sound card and sound recording software can easily measure the acoustic properties of their room. The procedure used in the example below was as follows:-

1. Connect the sound meter output to the sound card line in or microphone input if a line in is not available.
2. Set the meter gain to an appropriate level usually the 80 or 90dBA range for a line input level or maybe 120dBA for a microphone input.
3. Select track 44, 250Hz tone burst, on the cd player and set to continuous repeat.
4. Adjust an appropriate sound level without overloading the meter or sound input.
5. Record the tone burst, preferably at a 24 bit conversion quality and save.
6. Filter effects should be applied to the recorded waveform to remove unwanted noise and harmonics. For example, the recording shown below in Fig. 1 is a 250Hz tone burst recorded in a small domestic room with extra room treatment comprising 10 sq meters of absorption. The following was used.
   - High pass filtering at 150Hz, Butterworth, 6 pole
   - Low pass filtering at 320Hz, Butterworth, 6 pole
   - Removal of 2nd and 3rd harmonics may also be required.

   Steeper or closer filtering has to be avoided as this affects the rise and fall time of the waveform.
7. Examination of the waveform will reveal the effective reverberation time. The waveform below has a rise time to 70% of its final value of about 20ms. The standard reverberation time, RT60, is 10 times this value i.e. 200ms. However it can be seen that this method is inaccurate because of the complex nature of the waveform. The transient beats in the reverberant field are giving rise to ripples in the waveform.
   Close examination of the fall time shows that the transient has dropped to 1/100th or -40dB of the steady state value in about 200ms. The RT60 time by this method is therefore estimated as 300ms, 1.5 times the RT40 value.
8. Repeat the process at other frequencies to get a complete picture.

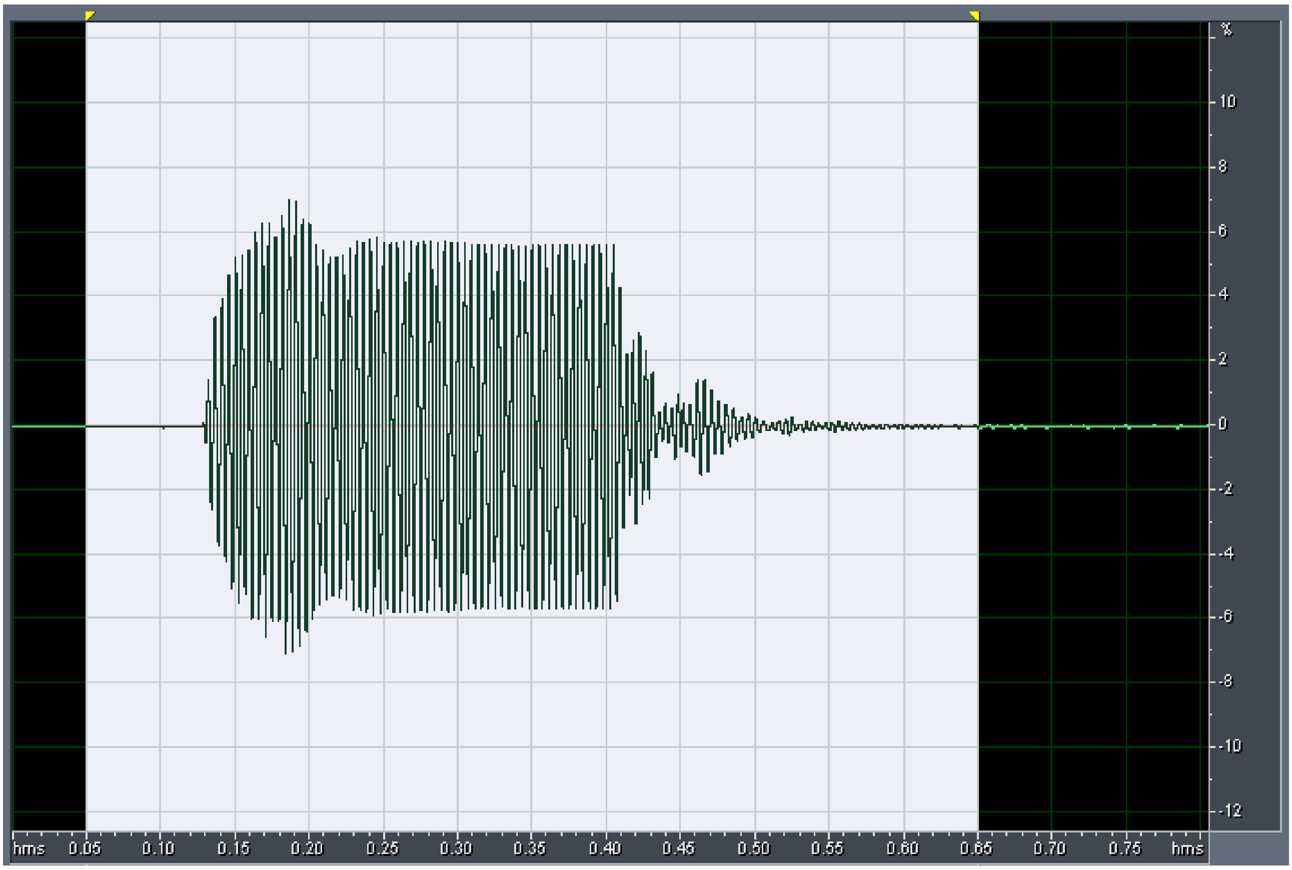

Fig. 1 Room transient, 250Hz

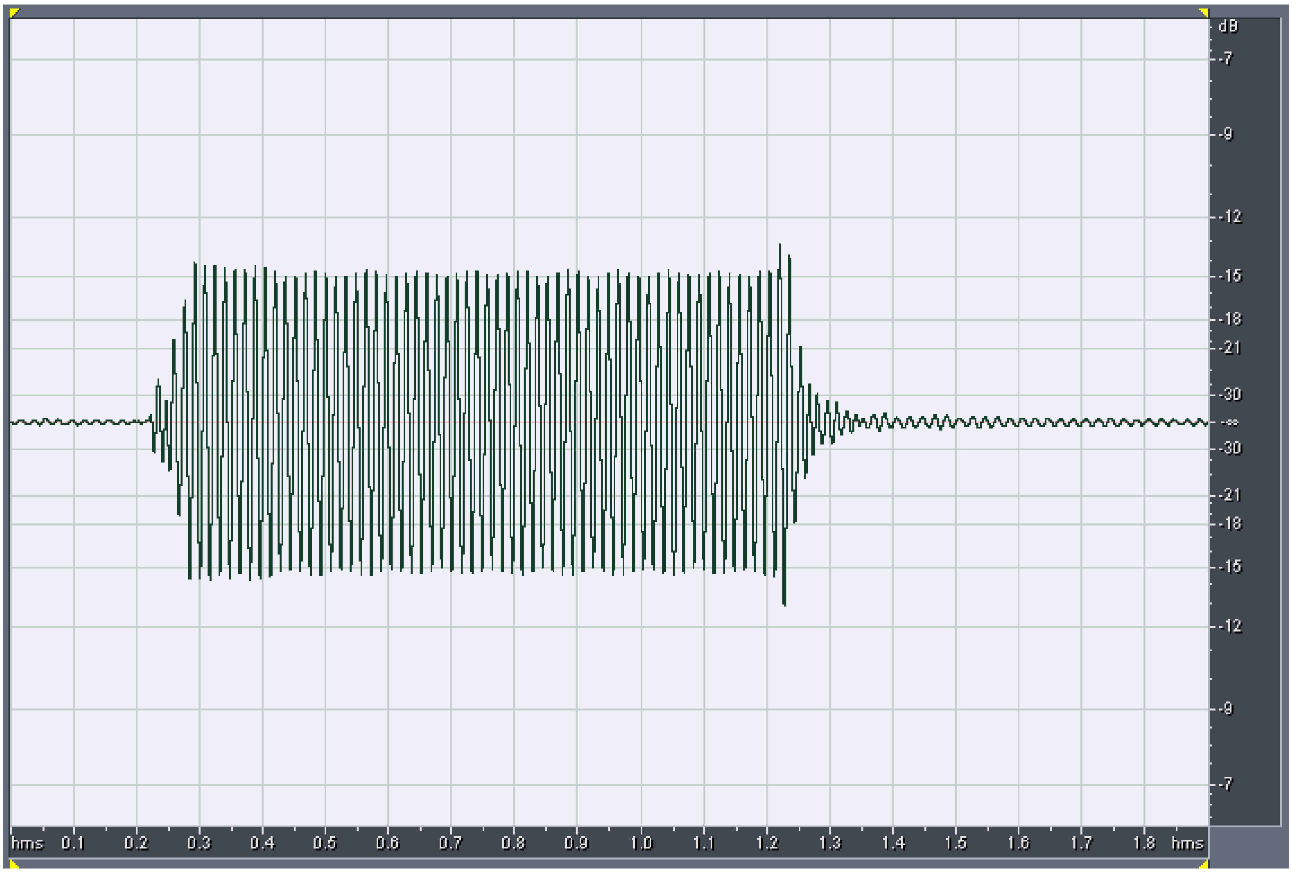

Fig. 2 Room transient, 62.5Hz

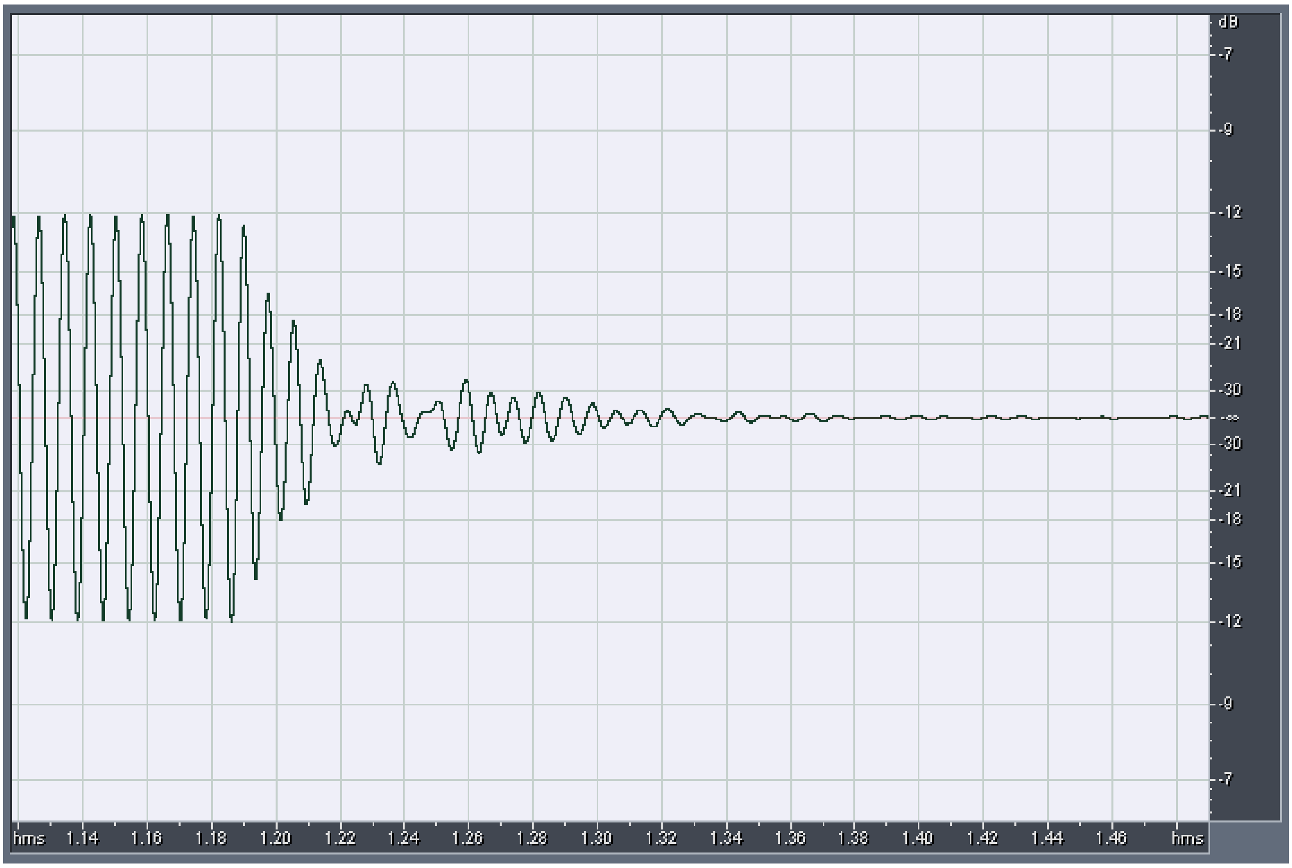

Fig. 3 Room transient, 125Hz

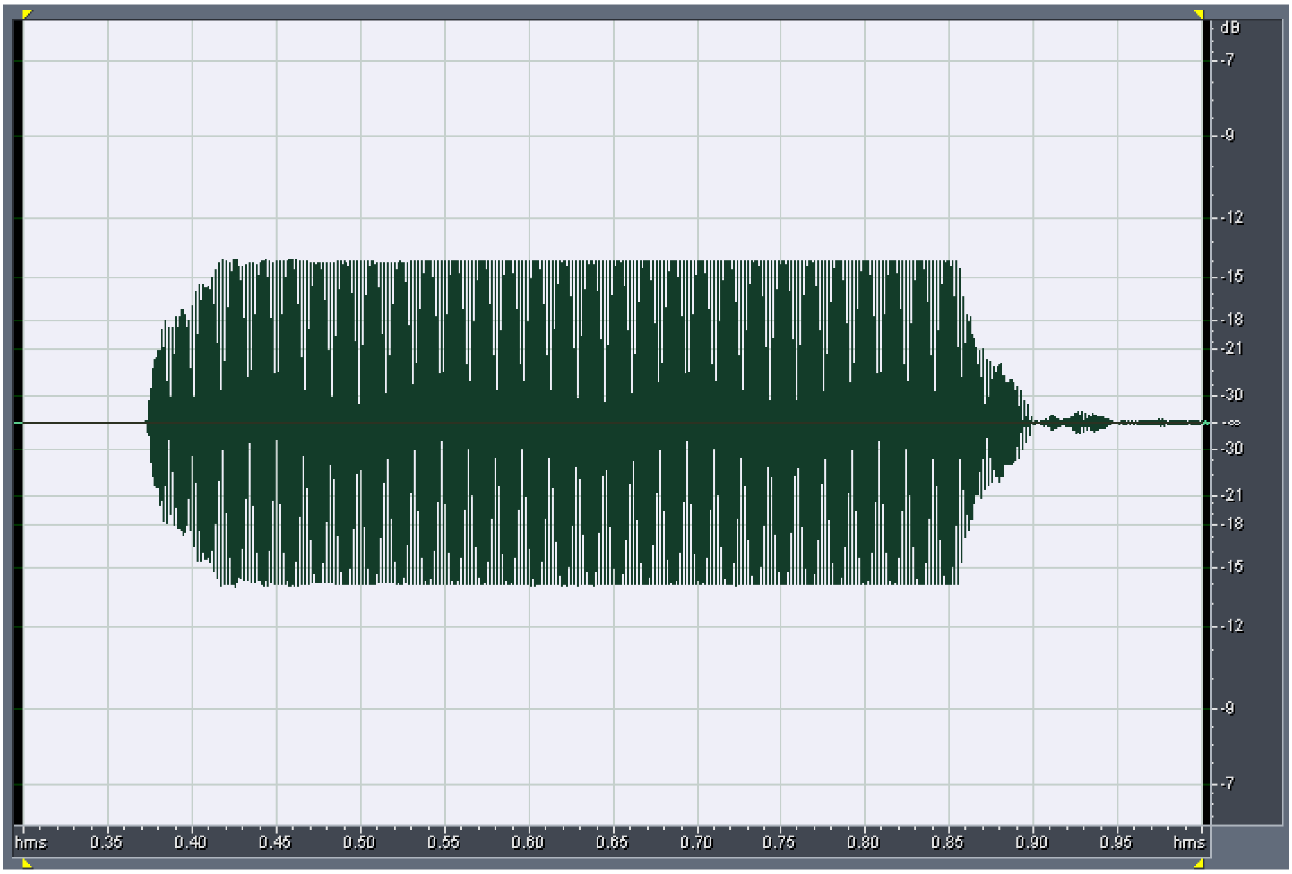

Fig. 4 Room transient, 500Hz

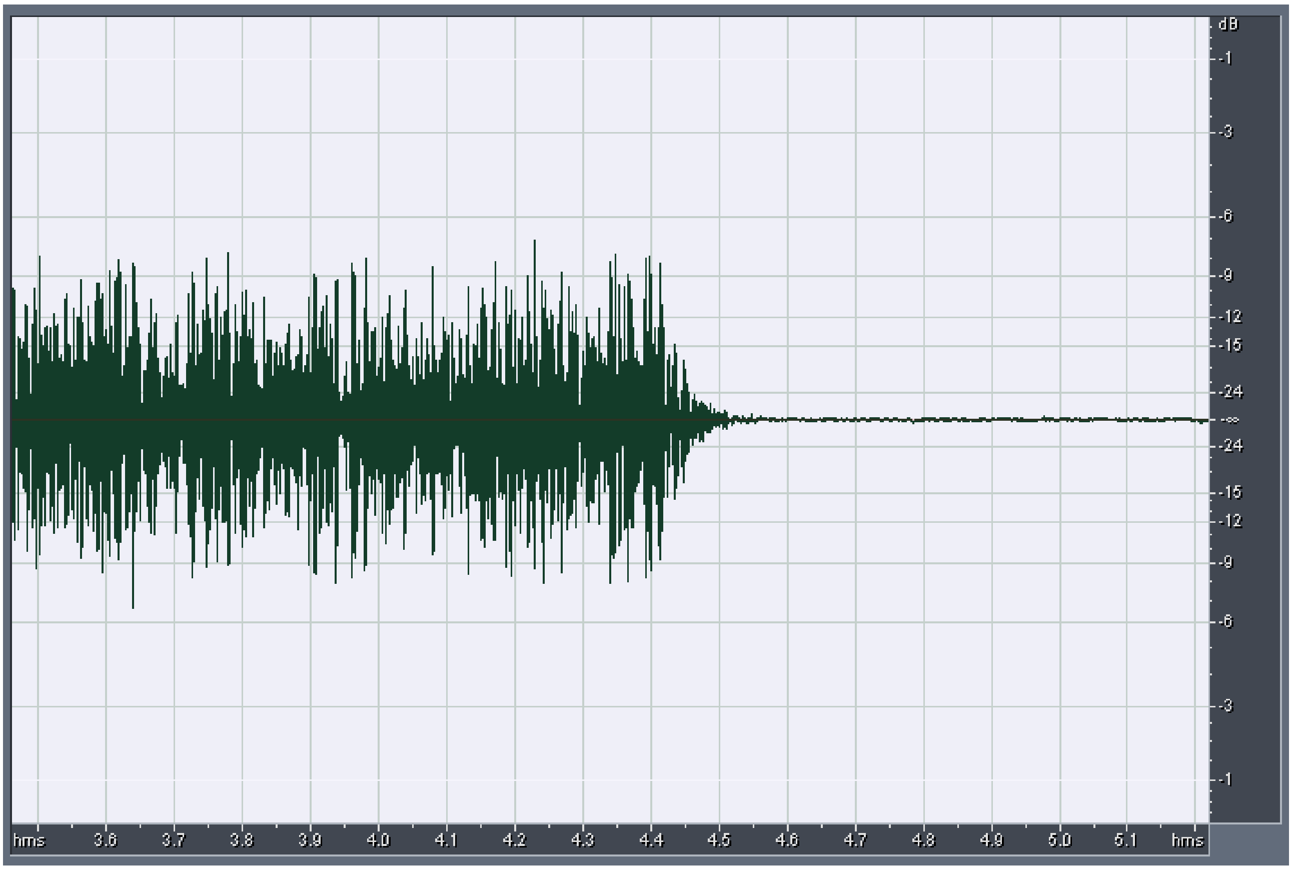

Fig. 5 Pink noise transient, 320Hz - 640Hz band

Figures 2 to 5 show further measurements, at different frequencies, made in the same room. The estimated RT60 reverberation time is from 300ms at low frequencies to 240ms at higher frequencies. In each case the decay time to 1/10th the steady state level (RT20) was estimated and then multiplied by 3 to give the value for

RT60. This process of extrapolation does assume that the decay rate is constant but is seems to be consistent in this case.

Early reflections may combine to seriously distort the start of the transient at either end of the waveform giving rise to unexpected peaks before the steady state reverberant field is established. These can be seen in Fig. 1 and 2 which make it difficult to determine the estimated start and stop of the transient. Moving the microphone in ¼ wave increments will provide a compromise solution.

In an attempt to avoid this problem, Fig. 5 shows an experiment using a transient waveform of single octave pink noise (track 7 on the cd). The estimated decay time to 1/10th the steady state value (the RT20 point) was done by measuring the rms value of small portions of the decaying transient to locate the required value.

Suggested Software

Most of the work carried out in this article uses **Adobe Audition** which is best suited to audio projects of a more technical nature. However this is relatively expensive. Minimum cost systems can be achieved using Open Source (Linux) operating systems and audio software. (See the www.audiophilerecordingstrust.org.uk, section 2 for more details.)
An excellent pc based Real Time Analyzer is available at reasonable cost from www.trueaudio.com .

Need help or more advice?

Email info@audiophilerecordingstrust.co.uk with your initial query and we will be pleased to offer further assistance.

Appendix

Plot 1: Comparison of Real Time Analyzer and Test Tone measurements