Summary

It is an accepted fact that the acoustic properties of a listening room have a dominating effect over the performance of high quality speakers intended for audiophile use.
Less well documented is the actual response of different speaker designs and drivers in acoustically treated rooms. This makes the subjective comparison and review of different designs more difficult. The main negative effects of acoustically treated rooms, especially with high absorption, (reverberation time < 0.2s) is to seriously unbalance the speaker response across the entire audio spectrum.
Simple yet effective tone controls are capable of equalizing all speaker responses in treated rooms. As these are low Q filters, they will not give rise to audible colouration.

Why acoustically treat listening rooms in the first place ?

1. Echoes from walls, floors and ceilings build up to give a sound field that may have little resemblance to the original recording. Research indicates the following:

- typical listeners usually prefer the presence of side reflections when listening to stereo left and right.
- musicians and trained listeners (recording engineers) prefer working situations with no side reflections.

The untrained listener prefers the presence of early side reflections which improve the feeling of spaciousness without damaging stereo imaging. Reflections from front and rear boundaries are of no real value to either listener and so may be absorbed.

2. Room resonances give rise to large peaks and troughs in the response from 20 – 150Hz. This gives uneven and confused bass and poor bass transients.

3. There needs to be an accurate balance between reverberant and direct sound for the speakers. This varies according to the recording method involved in the original recording. Multichannel recording methods with close microphoning, probably in a studio, does not yield any kind of ambiance to the recording. This may be added artificially later but a contribution from the listening room is preferred.

Multi channel playback of recordings require high absorption in the listening room for generally preferred results.

4. Room gain is a term used to describe the increase in bass output below 150Hz as a result of confining the speaker within room boundaries i.e. a typical corner placement. This cannot be overcome by typical acoustic treatment but it has to be dealt with in order to provide accurate bass.

The Speaker Response Problem in Treated Rooms

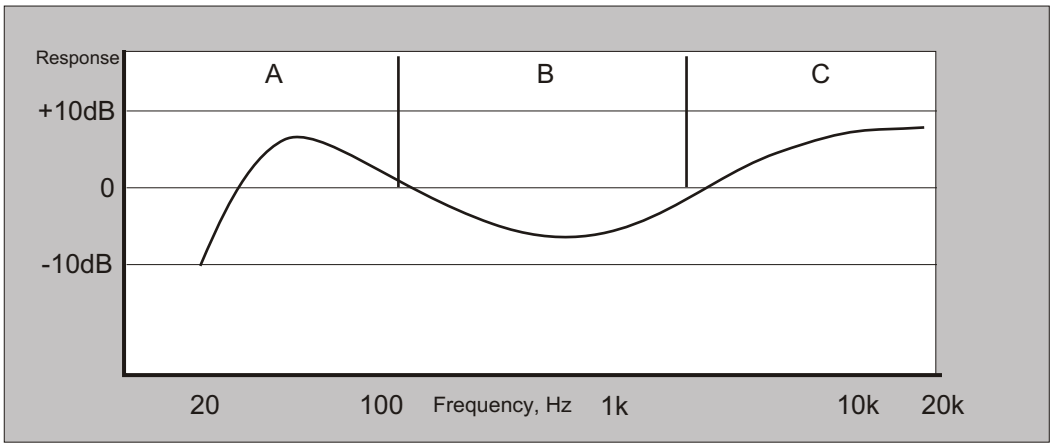

Fig. 1
Idealized speaker response in a room with significant room absorption. This relates to a closed box system with moving coil drivers.
It is a suggested simplified model of the response of a speaker, as described, with an excessively directional HF. This may be typical of any single full range driver design. It does not include room bass resonances.

Referring to Fig. 1

Region A - Room boundaries boost bass output which is eventually curtailed by the speaker LF response

Region B - Room absorption starts to reduce from about 400Hz affecting the reverberant sound field. Wide polar response in the lower mid range increases the effective level of absorption and decreases the mid range output. As the driver becomes more directional in the upper mid range, the output begins to rise again.

Region C - Directional HF continues to change the ratio of reverberant to direct sound giving a gradually rising HF response from about 2kHz

Some Examples

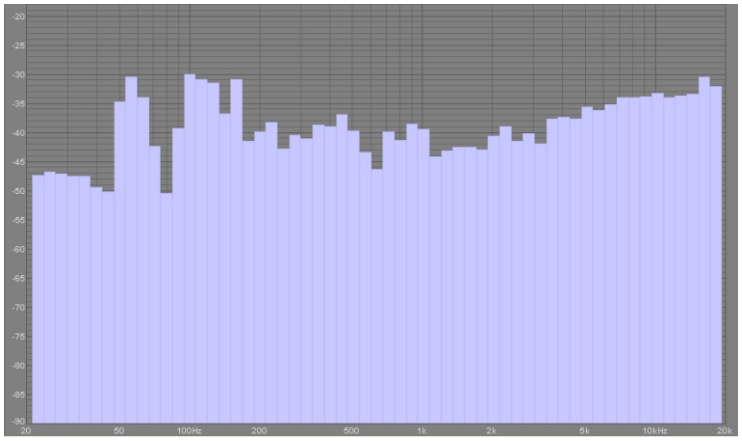

Fig. 2

Response of a conventional 2 way speaker in a room with relatively high absorption at 1.5 m distance. The unit has moving coil drivers, reflex bass loading, 25 mm dome tweeter,

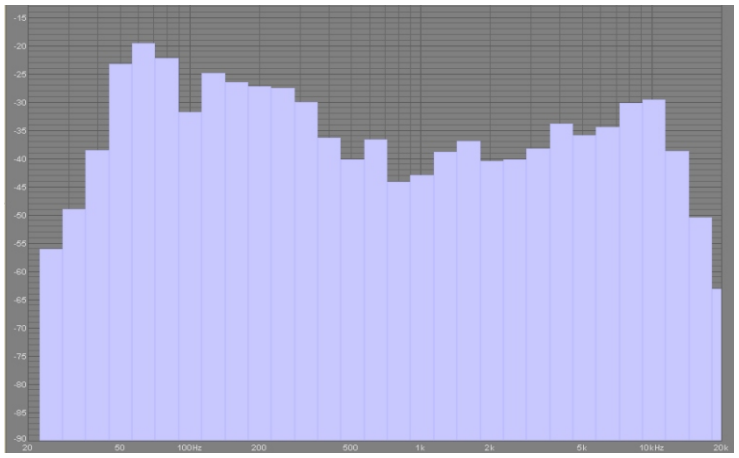

Fig. 3

Response of an unconventional 2 way speaker in the same room as Fig. 1 at 1.5 m distance. The unit has a dual coned full range main driver , and dipole bass below 170 Hz.

Discussion

Loudspeaker designers and reviewers instinctively favour products with good polar responses in the upper midrange and above.
From the point of view of room effects, this will minimise the unbalanced response in rooms with effective amounts of absorption. However, Fig. 2 indicates that traditional speakers designed with small drivers and dome tweeters are still unacceptably affected by the room.
Replacing room absorption with a balanced mixture of absorption and diffusion is an excellent but costly alternative.
A complete and more cost effective solution for critical applications is to equalise with simple, but specialised, tone controls. These would have to offer parametric controls with a view to varying frequency, level and slope in each of the 3 bands, A, B and C in Fig. 1.
The very low Q's required in such filters would make them totally benign in operation and should not be a cause for concern for the audiophile or professional user.

Conclusions

- All loudspeakers in acoustically treated rooms with high absorption, need to be equalised for critical use.
- This is especially true if mid range and hf drivers have inferior polar responses in the horizontal plane. This would include dual coned moving coil types, some arrays and large panel electrostatic drivers
- Significant errors may occur in a monitoring application that is not equalised.

Further discussions concerning the correction of room bass modes are the subject of a separate document concerning sub woofers from Marshall Choong.