Acoustics – Size and Modes of the Small Room for Home Theatre

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Abstract: **The size, shape and finishes of the small home theatre room decide the acoustic quality of the home theatre room. This paper analysis the various options for the design of home theatre room for musical instruments and for multi-purpose use. The determination of home theatre room sizes, proportions, shapes and finishes with their possible impact on the sound quality are discussed and also standing waves, room modes and even distribution of the modes in home theatre rooms are also addressed. At the design phase this would determine the final cost, floor areas utilized. In the home theatre acoustic the size, shape and modes are the major "elements". The frequency response and the reverberation time are the important part of entire system. If want to build a home theatre, will be starting with the actual room itself. The size and the shape of the room provide a significant impact on the performance of the home theatre and how to makes the room better sound quality for the home theatre are discussed.**

Keywords: **Acoustic, Room Size and Shape, Room Modes, Modal Resonance.**

I. INTRODUCTION

The most development of human and culture are speech and sound. Sound is the energy that transferred from the source by developmental sound wave through some medium. Almost in all the fields the acoustics is spread in our society viz. music, medicine, industrial production, etc…

The acoustic helps, to do noise problem analysis, to do industrial noise control, to make a sound proof room, and to understand the sound absorbing and reflection. The sound heard in a listening room is obtained by the combination of the electronics system and acoustics of the listening room. Specifically, the modal produced by the room be so significant they dominate the sound. So concentrate on the room design to minimize the relics at the low frequencies. Modes in small rooms frequently direct to sustain sound decays and uneven frequency responses – regularly referred to as pervading character (coloration). Problem arises at the low frequencies due to quite low modal density. Here we will be concerned ourselves with the first problem of choosing the good room dimensions.

II. ROOM ANALYSIS

A. Room Analysis

The shape and size of the studio room is a basic factor when designing a studio to attain a suitable acoustic environment with a standard speed of sound 343m/s. Because Shape and size manipulate the resonances a room naturally produces. Although rooms with parallel walls, floors and ceilings are preferred for studio rooms, to maximize the use of the available space the rooms in studio facilities are normally rectangular in size. Where rectangular rooms with parallel walls, floors and ceilings are adopted, care should be taken to determine the ratios of the room length, width and height.

To reduce the amount of healing wanted in the studio to clean sound can be reduced by building an acoustically suitable room.

Room Details: Volume – 17 m^3, Surface – 40 m2, RT 60 - .7 sec

B. Figures, Graphs and Tables

Table 1: Axial Mode & Frequency

Length		Width		Height	
Mode	Frequency	Mode	Frequency	Mode	Frequency
1 0 0	56.2295	0 1 0	66.2162	0 0 1	80.1401
2 0 0	112.459	0 2 0	132.432	0 0 2	160.280
3 0 0	168.688	0 3 0	198.648	0 0 3	240.420
4 0 0	224.918	0 4 0	264.864	0 0 4	320.560
5 0 0	281.147	0 5 0	331.081	0 0 5	400.700
6 0 0	337.377	0 6 0	397.297	0 0 6	480.841
7 0 0	393.606	0 7 0	463.513	0 0 7	560.981
8 0 0	449.836	0 8 0	529.729	0 0 8	641.121
9 0 0	506.065	0 9 0	595.945	0 0 9	721.261

Table 2: Tangential mode & Frequency

Length & Width		Length & Height		Width & Height	
Mode	Frequency	Mode	Frequency	Mode	Frequency
1 1 0	86.8697	1 0 1	97.8989	0 1 1	103.956
1 2 0	143.875	1 0 2	169.857	0 1 2	173.419
1 3 0	206.453	1 0 3	246.908	0 1 3	249.372
1 4 0	270.767	1 0 4	325.454	0 1 4	327.328
2 1 0	130.505	2 0 1	138.092	0 2 1	154.792
2 2 0	173.739	2 0 2	195.797	0 2 2	207.913
2 3 0	228.272	2 0 3	265.422	0 2 3	274.482
2 4 0	287.750	2 0 4	339.714	0 2 4	346.839
3 1 0	181.219	3 0 1	186.757	0 3 1	214.204
3 2 0	214.462	3 0 2	232.692	0 3 2	255.247
3 3 0	260.609	3 0 3	293.696	0 3 3	311.870
3 4 0	314.021	3 0 4	362.236	0 3 4	377.121
4 1 0	234.462	4 0 1	238.768	0 4 1	276.723
4 2 0	261.010	4 0 2	276.184	0 4 2	309.585
4 3 0	300.082	4 0 3	329.226	0 4 3	357.708
4 4 0	347.478	4 0 4	391.595	0 4 4	415.827

Table 3: Oblique mode & Frequency

Mode	Frequency	Mode	Frequency	Mode	Frequency	Mode	Frequency
1 1 1	118.189	1 1 2	182.307	1 2 1	164.689	2 1 1	153.147
2 2 2	236	2 2 1	191.331	2 1 2	206.691	1 2 2	215.383

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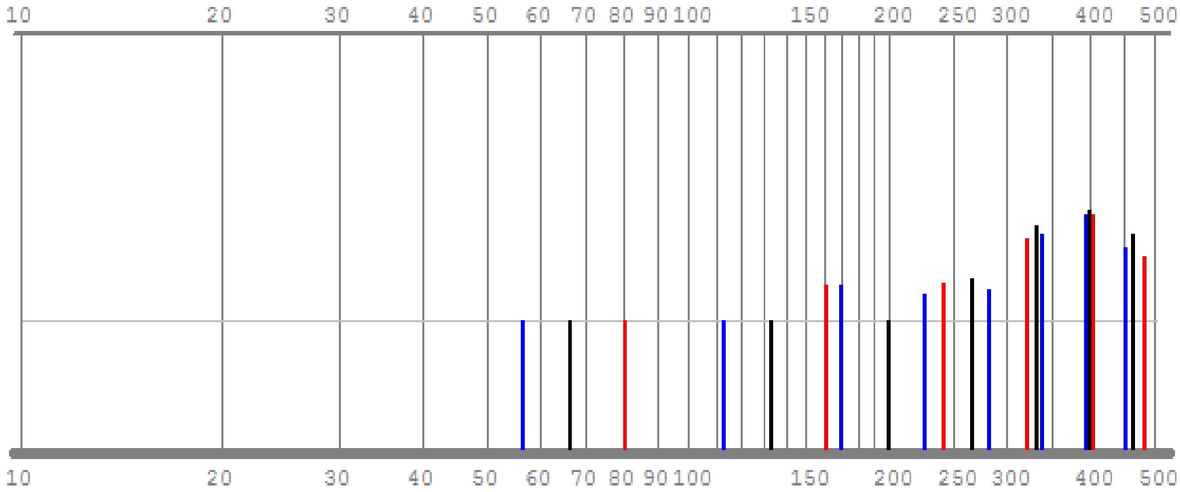
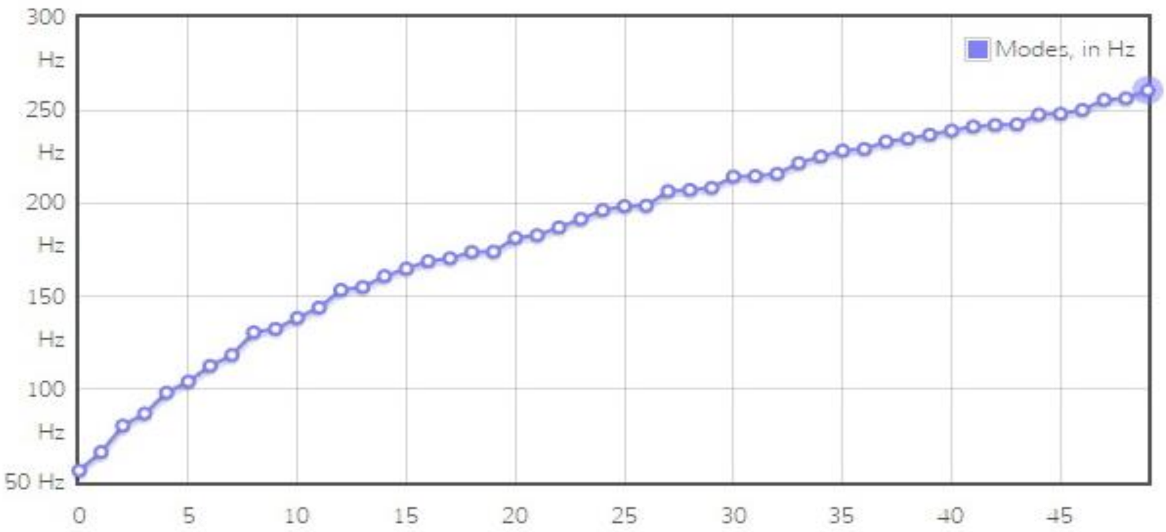


Relative mod strength Vs Frequency (Hz)

Fig.1. Room mode for 17 m3 room (Ratio 1.3:1.4:1.5)



Modes in Ascending Frequency

Fig.2. First 50 Modes (Frequency (Hz) Vs Modes in ascending frequency)

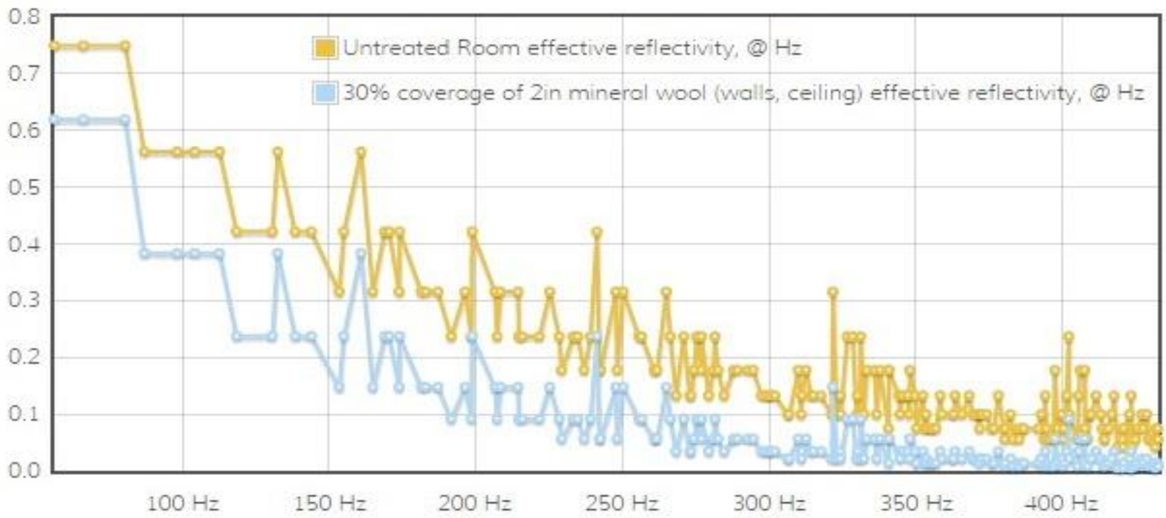


Fig.3. Reflectivity of each mode

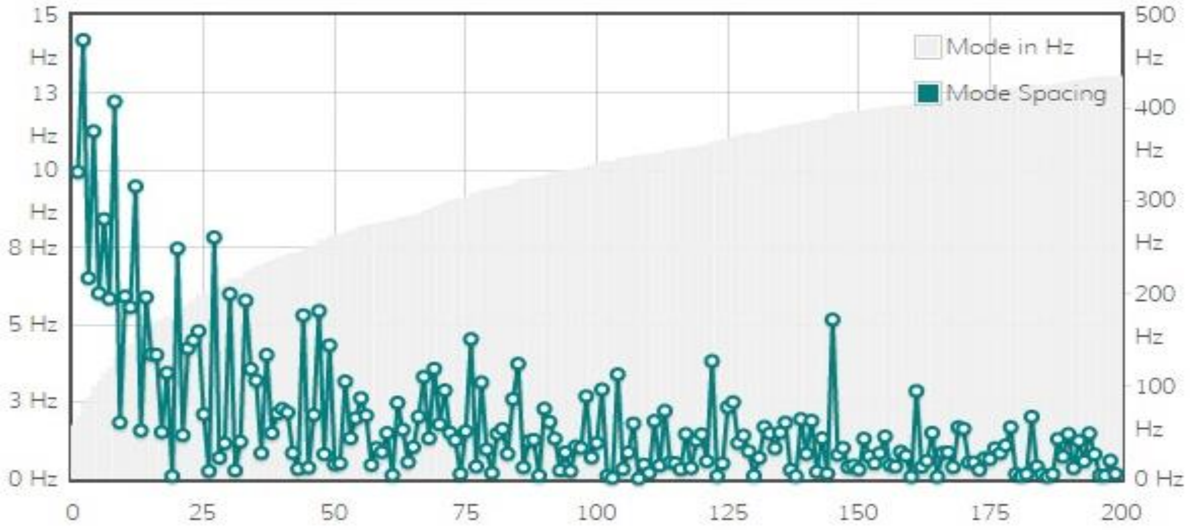


Fig.4. Mode spacing

C. Results

From the Fig 2 And the table 1 understood that the initial modal resonance happens at the frequency 56.3 Hz where the distance between the two borders is equal to half a wavelength. The first modal resonance at 56.3 Hz takes place for 10 ft long and next resonances takes place at multiples of this frequency.

From the mode spacing fig 4 identified that the mode spacing of low frequency are good enough but also not often spaced this leads to bad sound quality. The peak response error are identified at the mid range frequencies 132.48, 160.87, 198.73, 241.31, 321.75, 402.18 Hz. Observed that there are 79890 standing waves between 0 Hz and 500 Hz. The Fig 3 shows the results of reflectivity with 2" mineral wool provided, in the walls and ceiling, for the effective reflectivity 30 % coverage is essential. Average wall absorption of 30 % is estimated, So that the reverberation time will be reduced to .23 m/s.

III. CONCLUSION

Where rectangular room is proposed with the ratio of 1.3: 1.4: 1.5 (by R. Walker, 1996) [3]

Room if:
$1.1*(W/H) < (L/H) < 4.5*(W/H)-4$
$1.3 < 1.4 < 1.5$

The room modes and modes distribution where checked. Whatsoever the shape and size (10*8.5*7 ft) of the room, in the low frequency range where modes are sparsely spaced in frequency, directed to a poor sound quality.

In particular, this is the extremely extended sound decay of modes that make sound sustain and clear. By damping (adding absorption materials to) the modes this problem can be solved. This is best if the room has definite dimension and this helps in minimize the modal problems .So that the treat of the modes will be done easier (and cheaper).

Normally in rectangular room the peak frequency response error created by interference of naturally occurring axial standing waves are reduced by employing an acoustical bass absorber in the balanced room. The type of instrument and the loudness of the instrument are to be measured for the design of the small home theatre room. The wall insulation properties to be determined based on the instrument loudness and target background noise.

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