IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 13, Issue 7, July 2023, ||Series -I|| PP 28-33

Sinusoidal Tones as an Acoustical Measuring Method in a Recording Studio

Franco-Galván Carlos Angel[1], Castillo Flores Luis Alberto[2], Rodríguez-Vudoyra Héctor Miguel[3]
1 carlosangel.franco@correo.buap.mx, 2 castillo.f.luis.a@gmail.com, 3 hector.rodriguezvu@correo.buap.mx
Centro de Investigación de Estudios Sonoros de la Facultad de Artes (CIESFA) de la BUAP
Received 20 July 2023; Accepted 12 August 2023

Abstract
Acoustical measurements in a recording studio live room were carried out using an empirical version of Sweep Sinusoidal and software Impulse Response measurer based on Exponential Sweep Sinusoidal technique. The measures took place on strategic spots in the room, empirically used for sound recording. These spots are the back corners, and the middle of the live room. After reviewing measurements taken with the two methods, it was found that both are suitable for acoustical impulse response measures in rooms.
Keywords: Sweep Sinusoidal, acoustic measurements, room acoustics, impulse response.

I. Introduction

Sound recording studios need a good acoustical environment according depending on the sounds to be captured. More than often, changes on its walls, floors and ceilings are needed. Following previous works on acoustical measurements (Alonso & Franco, et. al. 2022), researchers in the Department of Arts (*Facultad de Artes)* at the Autonomous University of Puebla BUAP, Mexico decided to study the acoustical response of the recording studio at CIESFA (Centro de Investigación de Estudios Sonoros de la Facultad de Artes).

A two-stage experiment was carried out where amplitude was measured at different frequencies (80, 550 and 980 Hz). The first stage was measured on strategic sites in the live room of the recording studio, the chosen sites were those which were empirically known as good for recording certain sounds (e.g., bass and medium). Such data were obtained by checking the amplitude of sine waves played back at the above mentioned frequencies. Subsequently, a second set of amplitude measures at the same frequencies were done using a software impulse response measurer using Exponential Sweep Sinusoidal ESS. The document is organized as follows: After this introduction, section 2 describes the methodology applied. Section 3 states the experiment's aims. Section 4 contains a description of the room measured. The experiment is described in sections 5 and 6. Section 7 shows the results and conclusions are explained on section 8.

II. Background

Measuring the acoustical response of a building has become a standard in building recording studios and radio booths, recently (Tenutta et al., 2019) used this technique to refurbish audiometer cabins. The same technique was applied in the construction of a university auditorium (SALVADOR GIL SANCHIS, 2020). A similar method was used during the remodeling of public auditoriums in Valencia, Spain (Javier & Guzmán, 2020).

Among the different techniques to measure acoustical responses, the Exponential Sweep Sinusoidal ESS is one of the most notorious ones (Bjor & Nikolic, 2004). It is based on directly obtaining the venue´s impulse response which is necessary to know the reverberation time at different frequencies.

ESS (Exponential Sine Sweep) impulse measuring technique has gained considerable interest since Farina introduced it in 2000 and refined it in 2007 (Farina, 2007). As it is stated by (Guidorzi et al., 2015), in their study, the cited authors prove that Exponential Sweep Sinusoidal technique is more efficient in noise treatment than other popular techniques like Maximum Length Sequence. It is worth mentioning that Guidorzi also remarks that ESS has a smaller signal to noise SNR than MLS. In 2022, acoustic measurements at Maida Vale Recording Studios used several methods, but they confirmed that the best method is the Exponential Sine Sweep (Kearney et al., 2022).

For this experiment, the authors used an empirical method based on Sweep Sinusoidal technique compared with the ESS impulse response to measure acoustical behavior in certain spots in a recording studio live room. Empirical techniques are not to be dismissed as stated by (Halmrast & Buen, 2008) these researchers found out that the results differ little from those obtained in more formal techniques. They used a balloon explosion recorded to compare it with MLS obtained measurements.

III. Experiment aims

The main goal in this experiment was to investigate the acoustical treatment of the live room at the recording studio. This would clarify the authors its advantages and limitations when recording voice and instruments. A secondary objective is to document the live room´s impulse response values to keep them as a reference for future work. Two techniques for taking the measurements were used: ESS and a novel technique producing sine waves and measuring their amplitude at certain frequencies.

IV. Brief description of the live room

The recording studio of Facultad de Artes from Benemérita Universidad Autónoma de Puebla is located on level 3 of the Colegio de Música, located at Av. Cúmulo de Virgo No. 4 Reserva Territorial Atlixcátyotl, San Andres Cholula.

This place has the measure 8 meters high and 8.15 meters wide (see figure 1). Initially, the studio was a classroom and for a brief time, it was used as a conference room or concert hall. Since 2019, the place has been acoustically conditioned and isolated, so now the sound can be captured with great quality, becoming the recording studio of the Facultad de Artes. The recording booth is located on one side of the room. The spots chosen to measure were the back corners and the middle of the room. Both back corners are used to record bass sounds from 80 to 150 Hz. The middle of the room is basically the place were vocals and middle and high frequencies instruments are recorded.

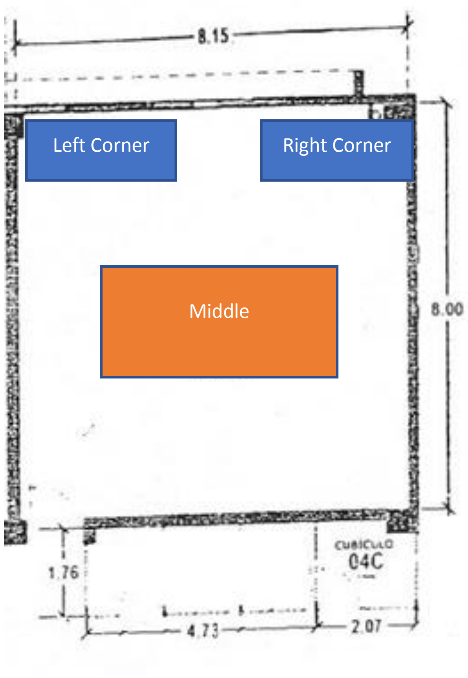

Figure 1. "Chosen spots for acoustical measuring"

V. Experimental Work

This part of the document describes how the measures were realized on the room. As it was discussed previously, the experiment had two stages: The first stage consisted of measuring the amplitude in certain areas after producing a sine wave tone. On the second stage, the same areas were measured using an ESS impulse response software based on MATLAB. The following instrumentals were employed:

Table 1 Instrumental

Element	Model
Decibel Meter	D525
Loudspeaker	Bose Soundlink
Wave Generator (Software)	Impulse Response Measurer on MATLAB.
Acoustical Retainer	Wooden frame covered with foam and fabric lined.
Microphone	Shure KSM 127

The procedure was as follows:
Montage: The loudspeaker was placed at different parts of the live room as shown on figure 1. According to norm ISO-3382 (*ISO 3382-1: Acoustics - Measurement of Room Acoustic Parameters. Part 1 : Performance Rooms*, 2009), the loudspeaker was placed at 1.2 m from the floor, the microphone was placed 2 m form the sound source. The room was closed, and the people who measured placed the decibel meter two meters form the sound source. For the second stage, the speaker was placed at the same places except that this time it was connected to the computer with MATLAB running.

1. Sound Level measures: Stage One

As it was mentioned before, five frequencies were chosen to measure the sound level: 80, 550 and 980 Hz. Table 2 shows the results obtained on the decibel meter. For the room corners, the frequency of 80 Hz was chosen since it is representative of bass sounds. As it was mentioned in section 2, the right corner is suitable for bass sounds recording. After measuring using the bass trap it was noticed that the bass trap works for the live room. Similar results were proved after measuring with and without retainer on the opposite corner.

The third place on the live room to measure was the center, were usually singers and string quartets are recorded. Table 3 shows the obtained results. For this section of the room sine tones at 550 Hz a 977 Hz were produced to measure sound pressure levels. Acoustical retainers were also used to prove their usefulness. As table 3 shows, the retainers do improve the sound pressure levels acquired.

Table 2 "Results of SPL on both corners of the live room."

Place	Frequency	SPL (dB)
Right Corner using Bass Trap	80Hz	74 dB
Right Corner without bass Trap	80Hz	65 dB
Left Corner using acoustical retainer	80Hz	87 dB
Left Corner without acoustical retainer	80Hz	73 dB

Table 3 "Results of SPL on the center of the live room."

Place	Frequency	SPL (dB)
With acoustical retainers	550 Hz	77 dB
	977 Hz	73 dB
Without acoustical retainers	550 Hz	57 dB
	977 Hz	64 dB

2. Sound Level measures: Stage Two

Trying to prove consistency on our measuring method, an impulse response measure using ESS was carried out. The instrument of choice was a software embedded in Matlab (citation). The software produces either sine waves or white noise and the response is captured by a microphone. For this stage the acoustical retainers were not removed due to technical needs of the live room for future productions.

The resulting levels are shown on the following figures. Figure 2 contains the values obtained by measuring the impulse response on the live room´s right corner. If looked at the bottom half of the figure, magnitude versus frequency are shown and the higher peaks occur at frequencies before 100 Hz. This result is consistent with the one obtained in the first stage of our experiment. It also confirms that the right corner of the live room is suitable for bass sounds recording.

Figure 3 shows the values read on the left corner of the live room. Just as the previous case, the main peaks are shown before the 100 Hz frequencies. This corner of the live room is rarely used for recordings since it works to storage the instruments and recording equipment. It might work also for bass sounds which are closer to the right side of the frequency spectrum. The data resembles that obtained in the first stage of the experiment.

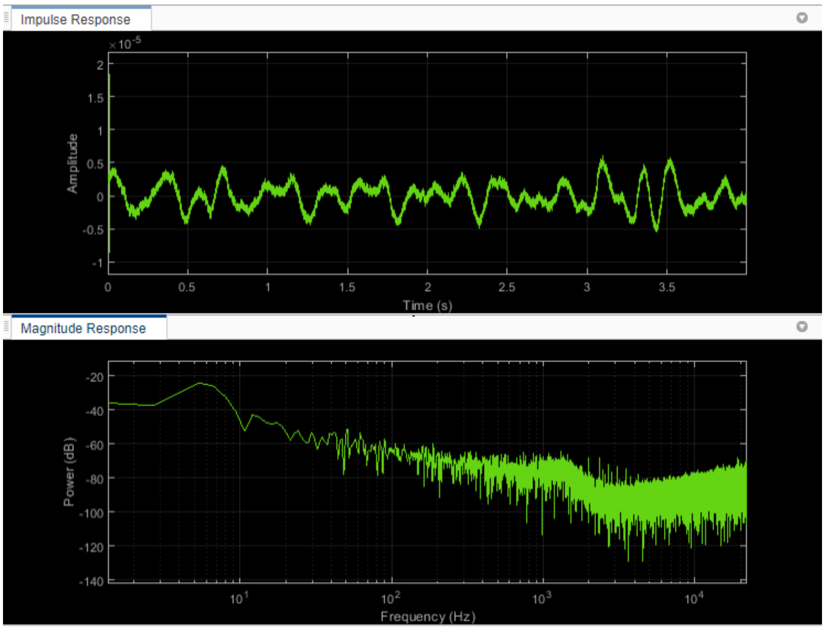

Figure 2 "Resulting values from Impulse response on Right Corner"

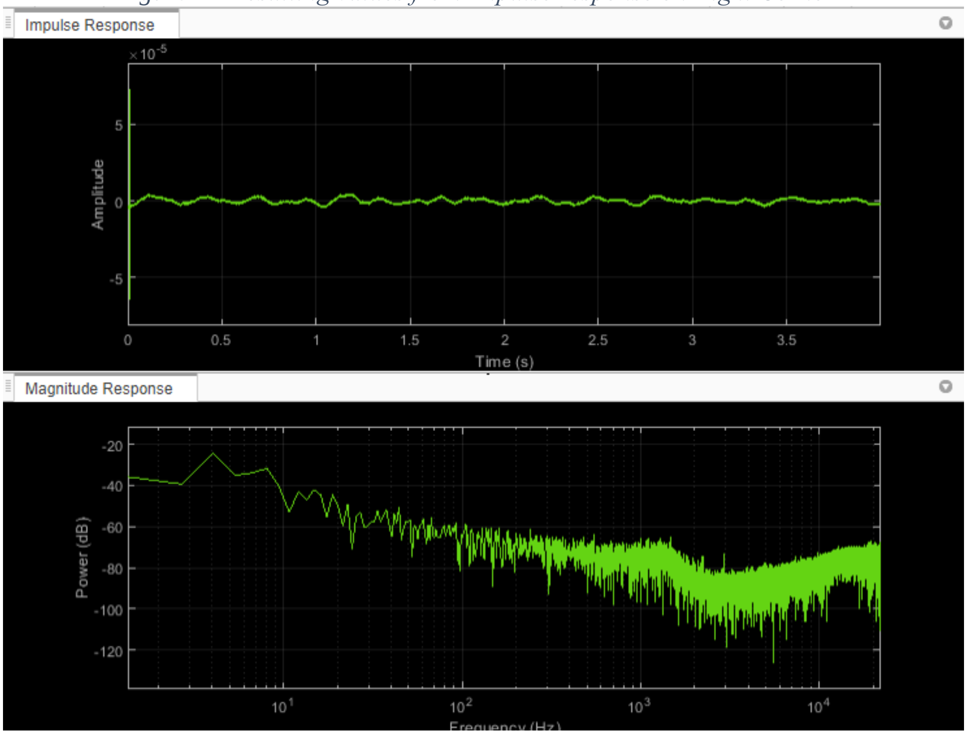

Figure 3 "Resulting values from Impulse response on Left Corner"

Finally figure 4 shows the impulse response measured at the center of the live room, where most of the recordings take place. If this figure is compared to table 3, frequencies at 557 Hz and 980 Hz appear at –50 and –60 dB respectively. Whereas in the first stage these values marked 75 and 77 dB respectively.

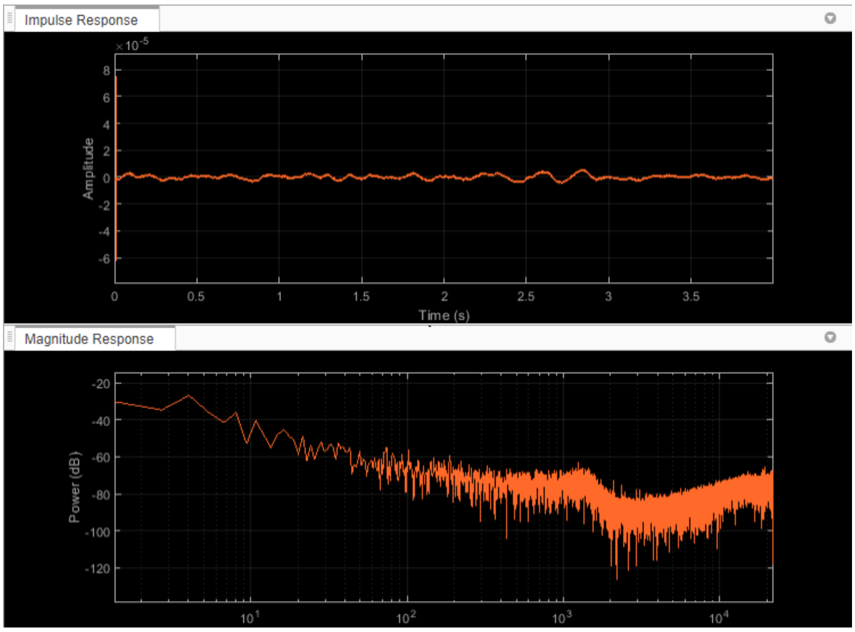

Figure 4 "Impulse Response Measures taken at the center part of the Live Room"

An interesting element to consider in the top bottom of the figure is the time response which is close to total flat. Little oscillations mostly between 2.5 and 3 seconds, it is clearly a spot with less reflections if we compare its impulse response with a that of the corners.

VI. Final Comments

It is well known that data can vary with a different sound source other than sinusoidal. Nevertheless, the results were good enough to assume that a similar condition will occur with multiple harmonics waves.

Just as it is discussed in specialized texts on acoustics (Everest & Pohlman, 2009), it was proved that frequencies under 100 Hz tend to be the most attenuated. Frequencies above 200 Hz to 1.5 kHz are usually well perceived anywhere in the building. For the case of the live room in the study, the back corners of the room can be confirmed as the most suitable for bass recordings and the center of the room is well conditioned for medium frequencies from 100 to 1 kHz approximately.

Placing carpets on strategic spots can attenuate certain frequencies in the spectrum but they should be used at the recording engineer or producer´s discretion.

The main concept inferred from the study is that the sine tones proposed method can be interchangeable with the impulse response measuring method since the acquired results are not dissimilar.

A disadvantage of the sine tones method, since it is an empirical, it does not work for VR proposes as did for (Kearney et al., 2022). The ESS is particularly recommended for larger buildings and also when de-reverberation and other processes are to be applied.

References

[1]. Alonso, G. I., & Franco, Carlos. (2022). Acoustical Measurements for a small College Auditorium using Sinusoidal Tones. 12(7), 25–31.

[2]. Bjor, O.-H., & Nikolic, I. (2004). Building and room acoustics measurements with sine-sweep technique. Cfa/Daga, 423–424.

[3]. Everest, A. F., & Pohlman, K. C. (2009). Master Handbook of Acoustics 5th ed.

[4]. Farina, A. (2007). Advancements in impulse response measurements by sine sweeps. Audio Engineering Society - 122nd Audio Engineering Society Convention 2007, 3, 1626–1646.

[5]. Guidorzi, P., Barbaresi, L., D'Orazio, D., & Garai, M. (2015). Impulse responses measured with MLS or Swept-Sine signals applied to architectural acoustics: An in-depth analysis of the two methods and some case studies of measurements inside theaters. Energy Procedia, 78, 1611–1616. https://doi.org/10.1016/j.egypro.2015.11.236

[6]. Halmrast, T., & Buen, A. (2008). Simplified room acoustic measurements. Proceedings - European Conference on Noise Control, 0032, 351–356. https://doi.org/10.1121/1.2932473

[7]. Javier, J., & Guzmán, G. (2020). Escuela de Artes Sonoras Proyecto Técnico Análisis y propuesta de implementación acústica y electroacústica.

[8]. Kearney, G., Daffern, H., Cairns, P., Hunt, A., Lee, B., Cooper, J., Tsagkarakis, P., Rudzki, T., & Johnston,

D. (2022). Measuring the Acoustical Properties of the BBC Maida Vale Recording Studios for Virtual Reality. Acoustics, 4(3), 783–799. https://doi.org/10.3390/acoustics4030047
[9]. ISO 3382-1: Acoustics - Measurement of Room Acoustic Parameters. Part 1 : Performance Rooms, (2009) (testimony of Organización Internaciónal de Normalización).
[10]. SALVADOR GIL SANCHIS. (2020). Universitat politècnica de valència.
[11]. Tenutta, M., Bertinatti, A., Vicente, F., & Maggi, A. L. (2019). Evaluación de características acústicas de cabinas audiométricas fija y móvil del cintra. XXXVII, 5–7.