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How Loud Would It Be If Every Alexa In The World Played "Despacito" At The Same Time?

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Abstract
The "This is so sad, Alexa play Despacito" meme has become incredibly widespread since its origin in 2018. The meme, which mocks posts of the form "This is so sad, can we get X likes", takes the form of an instruction to Alexa, the personal assistant software by Amazon, to play the song 'Despacito'. This paper aims to calculate, based on the physics of sound and the properties of a typical speaker, how loud the perceived volume would be if every Alexa-enabled device in the world were gathered in one place and, using the speaker for the Echo – the most common Alexa-enabled device – played the song 'Despacito' at the same time, assuming the sound produced by the Echo's speakers is perfectly in phase and undergoes only constructive interference. It is calculated that the volume would be 159 dB, equivalent to a shotgun blast. The maximum distance at which this would be audible over background noise of 50 dB is then calculated using the inverse square law relating sound intensity and distance, and is found to be 28 km.

Introduction
The refrain "This is so sad, Alexa play Despacito" has become widespread since the meme's origin in mid-2018 [1]. The meme mocks posts of the form "This is so sad, can we get X likes", and takes the form of an instruction to the personal assistant software Alexa to play the song 'Despacito' [2]. This paper will investigate how loud it would be if every Alexa-enabled device in the world played 'Despacito' in the same place at the same time, given the following assumptions. This paper will ignore, for the most part, the physical dimensions of the devices, and treat all the sound as being produced from a single point. The removal of this limitation is identified as potential future work. This paper will also assume that all devices produce sound at the maximum volume of the Echo dot, since Echo's are the most numerous Alexa-enabled devices and the maximum volume of the dot should be attainable by most other speakers. Finally, it is assumed that the sound produced by the devices is perfectly in phase, allowing the individual sound intensities to simply be summed to give the overall intensity.

Determining the sound intensity of a single Alexa-enabled device
To determine the perceived volume of every Alexa-enabled device simultaneously playing 'Despacito', the sound intensity produced by a single device must be known. Sound intensity is related to volume by the following expression [3]:

$$V = 10log_{10}\left(\frac{I}{I_0}\right), \quad (1)$$

where V is volume in decibels (dB), I is the sound intensity in Wm^{-2}, I_0 is a reference sound intensity (typically taken to be 1 pWm^{-2}) [3], the log base 10 of the ratio of $I : I_0$ is taken because the range of audible sound intensities spans several orders of magnitude, and the factor of 10 ensures that an increase of 10 dB in volume represents a factor of 10 increase in sound intensity. Therefore, given the volume of a single device, the sound intensity can be determined by rearranging equation (1) to get:

$$I = 10^{\mathrm{V}/10} \times I_0. \quad (2)$$

The 3rd generation Echo dot has a maximum speaker volume of 79 dB [4], this paper will use this value as

the volume of an Alexa-enabled speaker. Substituting this into equation (2) gives $I_{Alexa} = 7.9 \times 10^7 \times I_0$.

Determining the volume of all Alexa-enabled devices

Given the sound intensity calculated above, the combined sound intensity of all devices can now be considered. Assuming that the sound waves produced by the devices are completely in phase, there will only be constructive interference of waves, and the total intensity can be taken to be the sum of the individual intensities. Thus, to find the total sound intensity all that is required is the total number of Alexa-enabled devices. As of the start of 2019, Amazon reported that it had sold 100 million Alexa-enabled devices [5]. Using this figure, with the assumption that they all output through an Echo speaker, the total sound intensity of all 100 million devices is simply $10^8 \times I_{Alexa} = 7.9 \times 10^{15} \times I_0$. To determine the volume in dB, this intensity can be substituted back into equation (1), giving $V_{all\ Alexas} = 159$ dB. This is approximately equivalent to the inside of the speaker bin for a 5 kW speaker [6], or to a shotgun blast [7].

From how far away could this be heard?

Using this total sound intensity, it is also possible to calculate from how far away this would be audible. To be audible the sound's volume must be greater than that of ambient noise. Taking a value of 50 dB for the volume of ambient noise [8] gives a threshold volume below which the sound will no longer be audible. Sound intensity obeys an inverse square law [3]:

$$I(R) = \frac{P}{4\pi R^2}, \tag{3}$$

where $I(R)$ is the sound intensity a distance R from the source, and P is the power of the source. This can be rearranged to give:

$$\frac{I(R_2)}{I(R_1)} = \frac{R_1^2}{R_2^2}. \tag{4}$$

Letting $R_1 = 0.1$ m (the approximate diameter of an Echo [4]) and with $I(R_2) = 10^5 \times I_0$, the furthest distance at which the sound can be heard is:

$$R_2 = \frac{0.1}{\sqrt{\frac{10^5}{10^{18}}}} = 28\ km. \tag{5}$$

Thus, if every Alexa-enabled device in the world played 'Despacito' in the same place at the same time it would be audible from 28 km away.

Conclusion

Given the assumptions made in this model, if every Alexa-enabled device in the world were to play 'Despacito' at the same time it would be played at a volume of 159 dB, as loud as a shotgun blast, and would be audible from almost 30 km away. This model could be refined in the future by taking into account the effect of the speakers not all occupying the same point, which would result in many individual speakers' sound intensities being considerably reduced by the time the sound reached the edge of the arrangement of speakers chosen.

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