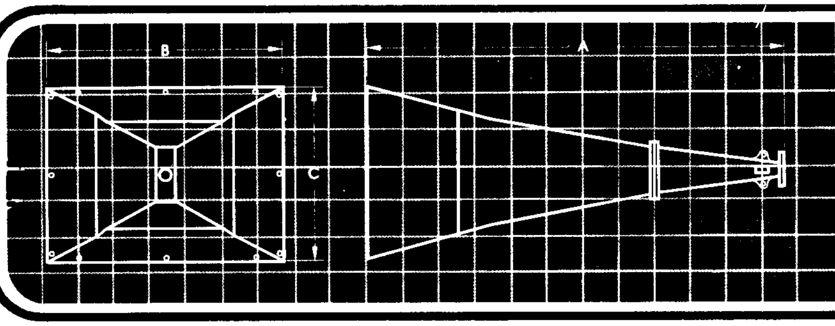

ALTEC ENGINEERING NOTES

Technical Letter No. 266

Articulation Loss of Consonants for Distributed Sound Systems

by Rex Sinclair

The Articulation Loss of consonants at a given location in a room with a single sound source is usually taken as the smallest of

$$AL = \frac{656\, d^2T^2}{QV}\,\%, \qquad (1)$$

$$AL = 9T\,\%, \qquad (2)$$

and

$$AL = 100\,\%, \qquad (3)$$

where d is the distance in feet from the source to the listening point, T is the reverberation time in seconds, V is the room volume in cubic feet and Q is the directivity factor of the source in the direction of the listening point.

It has been shown in Tech Letter 258 that for distributed sound systems in a room with parallel floor and ceiling, the maximum SPL (L_{max}) and the minimum SPL (L_{min}) relative to the axial SPL value of a single loudspeaker of the type used are given by

$$L = a + b \ln \sigma \qquad (4)$$

where a and b are constants tabulated in Tech Letter 258. For a square loudspeaker pattern,

$$\sigma = \pi r^2/x^2 \qquad (5)$$

where x is the loudspeaker spacing and r is the radius of the −6 dB coverage circle for which values can be found from Tech Letter 257. In the case of a hexagonal pattern, the spacing y can be shown to be [1].

$$y = x\,(4/3)^{0.25} \qquad (6)$$

hence by substitution into (4)

$$\sigma = 3.628\,(r/y)^2. \qquad (7)$$

With appropriate values of a and b, (4) can be used to give L_{max} and L_{min} in the listening plane of the ceiling array. It has also been shown [2] that for a distributed system

$$Q_{max} = \frac{Q(o)}{n}\,10^{0.1\,L_{max}} \qquad (8)$$

and

$$Q_{min} = \frac{Q(o)}{n}\,10^{0.1\,L_{min}} \qquad (9)$$

where Q(o) is the axial Q of a single loudspeaker and n is the total number of loudspeakers in the system. Substituting (8), (9) into (1) and taking the value of d to be the ear to ceiling height (h) yields

$$AL_{min} = \frac{656\, h^2T^2\, n}{VQ(o)\, 10^{0.1\,L_{max}}}\,\% \qquad (10)$$

and

$$AL_{max} = \frac{656\, h^2T^2\, n}{VQ(o)\, 10^{0.1\,L_{min}}}\,\% \qquad (11)$$

Thus for distributed systems with parallel planar floor and ceiling, the maximum articulation loss is the smallest of (2), (3) and (10) and the minimum articulation loss is the smallest of (2), (3) and (11).

Distributed system design methods for rooms whose floor and ceiling are not parallel and not necessarily planar are given in TM9. The essence of both methods presented therein is to make the SPL due to direct

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sound at the listening surface as independent of ceiling height as possible. As the reverberant field is usually taken as uniform throughout the entire space, then AL_{min} and AL_{max} should be the same as for some equivalent system with parallel planar floor and ceiling. It is convenient to express (10) and (11) in a form not including h.

For the parallel floor and ceiling case,

$$V = h\,S_c \qquad (12)$$

where S_c is the ceiling surface area. Substituting from (12) into (10) and (11) yields

$$AL_{min} = \frac{656\ VT^2\ n}{S_c^2\ Q(o)\ 10^{0.1\ L_{max}}}\ \% \qquad (13)$$

and

$$AL_{min} = \frac{656\ VT^2\ n}{S_c^2\ Q(o)\ 10^{0.1\ L_{min}}}\ \% \qquad (13)$$

The equations in (13) and (14) can be used with (2) and (3) for all systems designed according to TM11 or Method 1 of TM9, i.e. cases with parallel floor and ceiling, inclined floor and/or ceiling, and non-planar surfaces. Equations (10) and (11) can be used with (2) and (3) for systems designed by TM11 or Method 2 of TM9. For Method 2 of TM9 designs h is the minimum ear to ceiling height.

References

[1] Rex Sinclair, "The Design of Distributed Sound Systems From Uniformity of Coverage and Other Sound Field Considerations", AES Preprint No. 1824 (D-4), presented at the 70th AES Convention, New York, October 1981.

[2] Rex Sinclair and Ted Uzzle, "Off-axis Performance of Multiple Loudspeakers", AES Preprint No. 1825 (B-4), presented at the 70th AES Convention, New York, October 1981.