Electronic Sound Reinforcement of Rooms/Auditoriums

As we saw in the *EASE* Examples lecture notes, especially these days, with all the sophisticated, state-of-the-art/high-tech electronic sound reinforcement equipment that is readily available on the market, that there are many situations where the judicious use of electronic sound reinforcement equipment can make significant improvements in, or beneficially enhance the acoustic properties of places used for live musical entertainment, lecture halls, churches, auditoriums and concert halls, *etc*.

Depending on the individual/specific need(s) of the room, electronic reinforcement of sound can be in the form of either the direct, early or reverberant sound, however, usually it is the direct sound that is often in most need of reinforcement. In "dry" auditoriums, the reverberant sound can be reinforced, thereby increasing the reverberation time and hence the "liveliness" of the room. On the other hand, if excessive reverberation time or background noise interferes with clarity of speech in lecture halls and/or church settings, selective reinforcement of the direct sound over a selected range of frequencies can improve the situation in such rooms, but it also must be kept in mind that electronic reinforcement of direct sound likely will also increase the reverberant sound level(s) of such rooms.

We can characterize sound sources in a room not only by their acoustic power, P (Watts) emitted at the source, but also by their ***directivity factor***, Q (dimensionless). In general, both the sound power P and the directivity factor Q of a sound source will vary with frequency f, *i.e.* $P = P(f)$ and $Q = Q(f)$.

The sound power ***level*** L_{Pwr} logarithmically compares the acoustic power of the source, P to a ***reference*** acoustic power level, *e.g.* $P_o \equiv 10^{-12}$ *Watts*, thus: $L_{Pwr} \equiv 10\log_{10}(P/P_o)\ (dB)$.

Note that the average source power of a human speaking at a conversational level is typically $P \sim 10^{-5}\ Watts$, which corresponds to a sound power ***level***: $L_{Pwr} = 10\log_{10}\left(10^{-5}/10^{-12}\right) \sim 70\ dB$.

The directivity factor, Q is defined as the ***ratio*** of the sound intensity at a distance r in ***front*** of a source to the sound intensity ***averaged*** over ***all*** directions, the same distance r from the source:

$$Q \equiv \left|\vec{I}(\vec{r} = r\hat{z})\right| / \left\langle\left|\vec{I}(\vec{r})\right|\right\rangle_{\theta,\varphi}, \text{ where: } \left\langle\left|I(\vec{r})\right|\right\rangle_{\theta,\varphi} = \tfrac{1}{4\pi}\int_{\varphi=0}^{\varphi=2\pi}\int_{\theta=0}^{\theta=\pi}\left|\vec{I}(\vec{r})\right| d\cos\theta d\varphi$$

For a point sound source that radiates ***equal*** amounts of sound uniformly in ***all*** directions, $Q = 1$ (solid angle $\Delta\Omega$ subtended by the point sound source = $4\pi/Q = 4\pi$ steradians).

If this same point sound source is placed *e.g.* in the middle/center of a floor, far away from the walls, then $Q = 2$ (solid angle $\Delta\Omega$ subtended by point sound source = $4\pi/Q = 2\pi$ steradians).

If this point sound source is instead placed *e.g.* in the middle of a wall-floor or ceiling- wall junction, then $Q = 4$ (solid angle $\Delta\Omega$ subtended by point sound source = $4\pi/Q = \pi$ steradians).

If this point sound source is placed in a corner of a room, *e.g.* where the floor and two walls meet, then $Q = 8$ (solid angle $\Delta\Omega$ subtended by point sound source = $4\pi/Q = \pi/2$ steradians).