

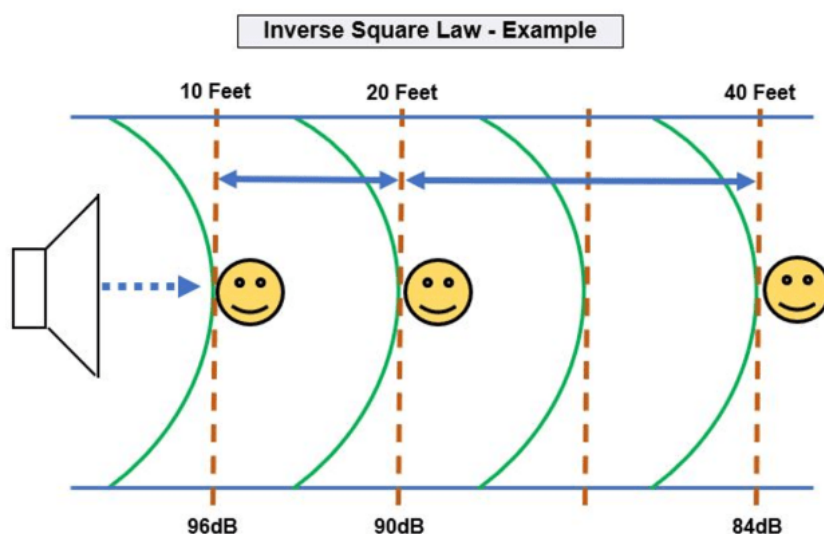
1 THE INVERSE SQUARE LAW IN SOUND

1.1 DEFINITION AND FORMULA OF INVERSE SQUARE LAW

The Inverse Square Law states that the intensity of sound decreases with the “square” of the distance.

Now what does that mean? Simply put, if you increase the “distance” (double the distance) between the “speakers” and the audience (move the speakers further away from the listeners) the sound pressure level (SPL) decreases by 6dB.

Example: Let's say the output of the speaker is 96dB at the listeners who are exactly 10 feet away from the speaker. If the listeners move to a position at 20 feet away, the sound pressure level will drop 6dB to 90dB. If the listener starts at 20 feet away, and moves to a position 40 feet away (doubling the distance) the sound pressure level will drop another 6dB to 84dB.



"The intensity of a sound decreases proportionally to the square of the distance from the source."

Mathematically:

$$I \propto 1/r^2$$

Where:

- I is the intensity of the sound
- r is the distance from the sound source

So, if you double the distance from the sound source, the intensity is reduced to one-quarter.

1.2 APPLYING THE LAW — DECIBEL DROP-OFF

Sound engineers work in decibels (dB). Here's how distance affects sound pressure level (SPL):

Every time the distance from the source is doubled, the SPL decreases by approximately 6 dB.

Example:

- At 1 meter: 90 dB SPL
- At 2 meters: 84 dB SPL
- At 4 meters: 78 dB SPL
- At 8 meters: 72 dB SPL

Note: This only holds true in a free-field (open space), without reflections.

1.3 Why This Matters in Sound Engineering

Microphone Placement

Close-miking increases clarity and reduces background noise. Moving a mic twice as far reduces its level by 6 dB.

Example: In studio recording, small changes in mic distance can drastically affect tonal balance and gain structure.

Live Sound and PA Design

Speaker placement must account for coverage and SPL drop-off. To ensure even coverage, engineers:

- Use delays and fill speakers
- Apply zoning in larger venues
- Use line arrays to counteract SPL loss

Signal Gain and Feedback Management

As performers move farther from stage monitors, SPL drops. Engineers compensate with more gain, which increases the risk of feedback. Better solution: Reposition monitors or performers to maintain optimal distance.

1.4 LIMITATIONS AND REAL-WORLD FACTORS

While the inverse square law is foundational, it assumes ideal conditions.

Factors that Alter the Law's Effects:

- Reflections (walls, ceilings)
- Absorption by surfaces or people
- Directionality of speakers
- Environmental factors: wind, temperature gradients

Quick Calculation Exercise

Q: A speaker emits 100 dB at 1 meter. What is the SPL at 4 meters?

Distance doubled twice = 1m → 2m → 4m = 6 dB + 6 dB = 12 dB drop

100 dB - 12 dB = 88 dB at 4 meters

The Inverse Square Law

The Inverse Square Law – A Quick Overview