**Fundamentals**

The spherical wave expansion of a point source is given by:

\[ p(r, \theta, \phi) = \frac{J_0(kr)}{r} \sin \theta \cos \phi \]

where \( p(r, \theta, \phi) \) is the sound pressure at a point \((r, \theta, \phi)\), \( J_0 \) is the Bessel function of the first kind of order zero, \( k \) is the wave number, \( r \) is the radial distance, \( \theta \) is the polar angle, and \( \phi \) is the azimuthal angle.

**Measurement**

Near Field Scanning

The sound field is measured using two cylindrical or hemispherical surfaces in the device's near field. While utilizing the same angular resolution of the directional pattern, the holographic approach requires a lower number of measurement points than traditional techniques.

**Applications**

Far Field Characteristics

The frequency response of the loudspeaker at any point in the far field can be calculated from near-field data.

- **Reference Measurement (Full Scan)**
- **Speaker 1**
- **Speaker 2**
- **Speaker 3**
- **Speaker 4**

**Holographic Loudspeaker Testing**

Accessing Radiated Sound in 3D Space

**Simplified Interpretation**

The CEA-2034 standard specifies meaningful loudspeaker responses at specific points, for home applications. This is helpful when considering the interaction between a room and when comparing loudspeakers regarding their performance at defined listening positions.

**Distributed Sound Sources**

The directivity of distributed sound sources (line arrays, sound bars) can be determined by measuring each individual transducer of the loudspeaker system. The measured characteristics of each transducer also includes shadowing and diffraction effects of the loudspeaker cabinet. After holographic processing, the total radiated sound pressure is calculated by superimposing the individual sound sources. By applying separate filters on each transducer (e.g., delay, gain), the directivity of the active system can easily be controlled (beam steering).