Brüel & Kjær

Dictionary

A reference dictionary of sound and vibration terms

1/3-octave Analysis

Constant Percentage Bandwidth (see CPB) spectrum analysis using 1/3-octave filters with bandwidth equal to 23% of the centre frequency.

1/3-octave Filter

See Third-octave Filter

1/n-octave Analysis

Analysis that is made on a fractional part of an octave where n is the variable. Commonly used values are 1/1-, 1/3-, 1/12-, and 1/24-octave.

10/100/1000 base T

10/100/1000 Mbit Ethernet transmitted over twisted pair cable.

10 base 2

10Mbit Ethernet transmitted over coaxial cable.

A/D Converter

Converts an analogue signal to a digital one.

A-Weighted Sound Level

A measure of sound pressure level designed to reflect the acuity of the human ear, which does not respond equally to all frequencies. The ear is less efficient at low and high frequencies than at medium or speech-range frequencies. Therefore, to describe a sound containing a wide range of frequencies in a manner representative of the ear's response, it is necessary to reduce the effects of the low and high frequencies with respect to the medium frequencies. The resultant sound level is said to be A-weighted, and the units are dBA. The A-weighted sound level is also called the noise level. Sound level meters have an A-weighting network for measuring A-weighted sound level. For broadband sounds, the A-weighted sound level indicates approximate relative loudness. See A-weighting.

A-weighted Sound Pressure Level

The sound pressure level of a signal which has been passed through an "A" weighting filter whereby both low and high frequency components are attenuated without affecting the component near 1000 Hz. The unit is the decibel, but it is usual to distinguish between this and other uses of the decibel by writing the unit as dB(A). See Frequency Weighting.

A-weighting

A frequency-response adjustment of a sound level meter that makes its reading conform to human response. The sensitivity of the human ear is frequency dependent. At low and high frequencies, the ear is not very sensitive, but between 500 Hz and 6 kHz the ear is very sensitive. The A-weighting filter is a broadband filter that covers the interval from 20 Hz to 20 kHz. The shape of the A-weighting curve approximates the frequency sensitivity of the human ear. So the A-weighted value of a noise source is an approximation to how the human ear perceives the noise.

Abffusor

A proprietary panel offering both absorption and diffusion of sound.

Absorption

A property of materials that reduces the amount of sound energy reflected. The introduction of an absorbent into the surfaces of a room will reduce the sound pressure level in that room by not reflecting all of the sound energy striking the room's surfaces. Absorption reduces the resulting sound level produced in the room by energy that has already entered the room

Absorption Coefficient

A measure of the sound-absorbing ability of a surface. It is defined as the fraction of incident sound energy absorbed or otherwise not reflected by a surface. Unless otherwise specified, a diffuse sound field is assumed. The values of the absorption coefficient range from about 0.01 for marble slate to almost 1.0 for long absorbing wedges often used in anechoic rooms. And vary with the frequency and angle of incidence of the sound. Usually measured in octave bands.

AC Coupling

The connection of a signal from one circuit to another in a manner that rejects DC components. See also DC Coupling.

Accelerance

The frequency response function of acceleration/force. Also known as inertance.

Acceleration

A vector quantity that specifies rate of change of velocity.

Acceleration Due to Rotational Motion

$G = 0.000028\ 42\ r\ n^2$

where:

- G = acceleration, in g
- r = radius arm, in inches
- n = revolutions per minute

$G = 0.10225\ rf^2$

where:

- r = radius of arm, in inches
- f = revolutions per second

$G = 4.02568\ rf^2$

where:

- r = radius of arm, in meters
- f = revolutions per second

Acceleration Formulae

Multiply	**by**	**to obtain**
acceleration due to gravity (g)	9.80665	meters/second^2
	32.174	feet/second^2
	386.088	inches/second^2
cm/second^2	0.010	meters/second^2
feet/second^2	0.3048	meters/second^2
inches/second^2	0.02540	meters/second^2

Accelerometer

A sensor whose electrical output is proportional to acceleration, these transducers are intended for measurement of vibrations. A transducer whose output is an electrical signal directly proportional to acceleration. The output is usually produced by the acceleration of a seismic mass, which applies a force to a piezoelectric crystal, thereby generating a current proportional to the applied force. This current is then amplified for processing and analysis.

Accuracy

How close a measurement is to the absolute quantity.

Acoustic and Vibration Decibels

All quantities are expressed in root-mean-square (rms) values (for interpolations, see Decibel Formulae).

	Acceleration	**Velocity**	**Sound Pressure Level in Air**	
dB	**g**	**m/s**	**Pa (N/m^2)**	**psi**
0	1 ´ 10^{-6}	1 ´ 10^{-8}	2 ´ 10^{-5}	2.90 ´ 10^{-9}
20	1 ´ 10^{-5}	1 ´ 10^{-7}	2 ´ 10^{-4}	2.90 ´ 10^{-8}
40	1 ´ 10^{-4}	1 ´ 10^{-6}	2 ´ 10^{-3}	2.90 ´ 10^{-7}
60	1 ´ 10^{-3}	1 ´ 10^{-5}	0.02	2.90 ´ 10^{-6}
80	.01	1 ´ 10^{-4}	0.2	2.90 ´ 10^{-5}
100	0.1	1 ´ 10^{-3}	2.0	2.90 ´ 10^{-4}
120	1.0	0.01	20	2.90 ´ 10^{-3}

140	10	0.1	200	0.0290
160	100	1 .0	2 ´ 10^3	0.290
180	1000	10	2 ´ 10^4	2.90

Reference Levels

- Sound Power: p_0 = 1 pW = 10^{-12} W = 10^{-5} erg/s
- Airborne Sound Pressure: p_0 = 20 mPa = 0.0002 mbar = 0.0002 dyne/cm^2
- Waterborne Sound Pressure: p_0 = 1 mPa = 10^{-5} mbar = 10^{-5} dyne/cm^2
- Acceleration: a_0 = 1 mg, where g = 9.80665 m/s^2 = 386.089 in/s^2
- Velocity: v_0 = 10^{-8} m/s = 10^{-6} cm/s

1 psi rms corresponds to 170.8 dB re 20 mPa

1 atmosphere = 14.70 psi

Acoustic Emission

The detected energy that is generated when materials are deformed or break. For rolling-element bearing analysis, it is the periodic energy generated by rolling over particles or flaws and detected by the display of the bearing flaw frequencies.

Acoustic FRF

FRF in airborne contribution measurements (sound pressure/volume velocity). Also referred to as AFRF.

Acoustic Holography

A common term for a set of techniques in which a sound field is measured at multiple points on a surface, and based on that all sound field parameters can be mapped within a volume around the measurement surface. Typically, measurements are taken at some small distance from a sound source and used for calculation of pressure, particle velocity and/or sound intensity on or near the source surface. See also NAH and SONAH.

Acoustic indicator

In airborne contribution measurements, the position where one measures to calculate strength at source points.

Acoustic Reflex

Bilateral contraction of the stapedius and/or tensor tympani muscles in response to an auditory or other eliciting stimulus.

Acoustic Reflex Threshold (ART)

The least sound pressure level of a sound that elicits the acoustic reflex.

Acoustic source

In airborne contribution measurements, one or several source points.

Acoustic Trauma

Damage to the hearing mechanism caused by a sudden burst of intense noise, or by a blast. The term usually implies a single traumatic event.

Acoustical Louver

A specially built louver designed with sound-attenuating baffles for reduction of airborne sound.

Acoustics

The science of the production, control, transmission, reception and effects of sound and of the phenomenon of hearing. The effect a given environment has on sound. The physical qualities of a room or other enclosure (such as size, shape) that determine the audibility and perception of speech and music within the room.

Active Intensity

The propagating part of a sound field, producing a net flow of sound energy.

Active Noise Control

The cancellation of sound waves by introducing a mirror image of the original sound wave, 180 degrees out of phase, into the sound path.

Active side

In structure-borne contribution measurements, the side which exerts/sends energy (for example, the engine) Also referred to as Engine Side. Note: There may be sub-frames in a measurement setup, which could be considered both part of the vehicle’s body and engine – it is up to the user to determine what to classify these in his SPR Model.

Active Sound Field

A sound field in which the particle velocity is in phase with the sound pressure. All acoustic energy is transmitted; none is stored. A plane wave propagating in free field is an example of a purely active sound field and constitutes the real part of complex sound field.

Acum

The unit of measurement for sharpness. 1 acum is the sharpness of a 60 dB narrow-band noise, one critical band wide with a centre frequency of 1 kHz.

Admittance (aural)

The reciprocal of Impedance. See Immittance.

AES

Audio Engineering Society.

AI

See Articulation Index.

Airborne Contribution

Noise from airborne sources (radiating engine surfaces, intake/exhaust orifice, etc.) that is part of the total sound heard in a vehicle's interior

Airborne Sound

Sound that reaches the point of interest by propagation through air.

Algorithm

A specific procedure for solving mathematical problems. An FFT is an algorithm.

Aliasing

To digitise an analog signal for processing in digital instruments such as an FFT analyzer, it first must be periodically sampled, the sampling process occurring at a specific rate called the sampling frequency. As long as the sampling frequency is more than twice as high as the highest frequency in the signal, the sampled wave will be a proper representation of the analog waveform. If, however, the sampling frequency is less than twice as high as the highest frequency to be sampled, the sampled waveform will contain extraneous components called "aliases". The generation of aliases is called aliasing. An example of aliasing sometimes occurs in motion pictures, as for instance when the wagon wheels in a Western seem to be going backward. This is optical aliasing, caused by the fact that the frame rate of the movie camera (24 frames per second) is not fast enough to resolve the positions of the spokes. Another example of optical aliasing is the stroboscope, where a moving object is illuminated by a flashing light and can be made to appear stationary, or move backward. Aliasing must be avoided in digital signal analysis to prevent errors, and FFT analyzers always contain low-pass filters in their input stages to eliminate frequency components higher than one-half the sampling frequency. These filters are automatically tuned to the proper values as the sampling frequency is changed, and this occurs when the frequency range of the analyzer is changed.

Aliasing Error

An error in digital sampling in which two frequencies cannot be distinguished. Caused by sampling at less than twice the maximum frequency in the signal.

Alignment

A condition whereby the axes of machine components are coincident, parallel or perpendicular, according to design requirements, during operation.

Ambience

The distinctive acoustical characteristics of a given space.

Ambient Noise

The total of all noise in the environment – factory noise, traffic noise, birdsong, running water, etc. – including the noise from the source of interest. See also Background Noise, Residual Noise and Specific Noise.

Ambient Noise Level

The total noise level in the acoustic environment, including the noise source(s) of interest.

Ambient Sound

The combination of all near and far sounds, none of which is particularly dominant.

American National Standards Institute

Known as ANSI, this is a federation of American organisations concerned with the development of Standards. Committees of industry experts draft ANSI Standards.

Amplification Factor (Q)

The amount of mechanical gain of a structure when excited at a resonant frequency. The ratio of the amplitude of the steady state solution (amplitude at resonance) to the static deflection for the same force F at frequency 0. The amplification factor is a function of the system damping. For a damping ratio = 0 (no damping) the amplification factor is infinite, for = 1 (critically damped) there is no amplification.

Amplitude

The instantaneous magnitude of an oscillating quantity such as sound pressure. The peak amplitude is the maximum value. In a vibrating object, amplitude is measured and expressed in three ways: Displacement, Velocity and Acceleration. Amplitude is also the y-axis of the vibration time waveform and spectrum; it helps define the severity of the vibration.

Amplitude Demodulation

see Envelope Analysis.

Amplitude Distortion

A distortion of the wave shape of a signal.

Amplitude Distribution

A representation of time-varying noise indicating the percentage of time that the noise level is present in a series of amplitude intervals.

Amplitude Probability

Used to investigate the amplitude distribution of signals.

Amplitude Scale (logarithmic)

See Logarithmic Amplitude Scale. Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale. But a logarithmic scale shows prominent vibration components equally well at any amplitude. Moreover, percent change in amplitude may be read directly as dB change. Therefore, noise and vibration frequency analyses are usually plotted on a logarithmic amplitude scale.

Analog

Quantities in two separate physical systems having consistently similar relationships to each other are called analogous. One is then called the analog of the other. The electrical output of a transducer is an analog of the vibration input of the transducer as long as the transducer is not operated in the non-linear (overloaded) range. This is in contrast to a digital representation of the vibration signal, which is a sampled and quantisised signal consisting of a series of numbers, usually in binary notation.

Analog Signal

An electrical signal whose frequency and level vary continuously in direct relationship to the original electrical or acoustical signal.

Analog-to-Digital Conversion

The process of sampling an analog signal produces a series of numbers that is the digital representation of the same signal. The sampling frequency must be at least twice as high as the highest frequency present in the signal to prevent aliasing errors. See A/D Converter and Aliasing Error.

Analog-to-digital converter

See A/D converter.

Analytical Modal Analysis

This is usually made using the finite element method to compute a mass matrix and a stiffness matrix, which are used in a model to represent the dynamics of a structure.

Anechoic

Without echo.

Anechoic Chamber

See Anechoic Room

Anechoic Room

A room designed to suppress internal sound reflections. Used for acoustical measurements. The boundaries absorb nearly all the incident sound, thereby, effectively creating essentially free-field conditions.

Angles

Multiply	by	to obtain
cycle (360°)	6.283	radians
degree	0.017453	radians
hertz (Hz)	6.283	radians/second
rev./minute	0.1047	radians/second
radians	57.2958	degrees
grade	0.900	degrees

Angularity

The angle between two shaft centre lines; this angle is the same at any point along either centreline. It is normally specified in rise/run.

Animation

Refers to a kind of "slow motion movie" that allows easy visualisation of, for example, a vibrating structure.

ANSI

See American National Standards Institute.

Anti-aliasing

Anti-aliasing filters are essential for making a correct frequency analysis. They remove components above the Nyquist frequency (half the sampling frequency). If such components are present in the signal when it is sampled, they lead to errors in the frequency domain functions, as they show up at lower frequencies (aliasing).

Anti-aliasing Filter

The low-pass filter in the input circuitry of digital signal processing equipment such as an FFT analyzer that eliminates all signal components higher in frequency than one-half the sampling frequency. See Aliasing.

Anti-resonance

A phenomenon in an electric, acoustic, or other such system in which the impedance is tending to infinity.

Apodize, Apodization

To apodize is to remove or smooth a sharp discontinuity in a mathematical function, an electrical signal or a mechanical structure. An example would be to use a Hanning Window in an FFT analyzer to smooth the discontinuities at the beginning and end of the sample time record. See also Hanning Window.

ART

See Acoustic Reflex Threshold.

Articulation

A quantitative measure of the intelligibility of speech; the percentage of speech items correctly perceived and recorded.

Articulation Index (AI)

A numerically calculated measure of the intelligibility of transmitted or processed speech. It takes into account the limitations of the transmission path and the background noise. The articulation index can range in magnitude between 0 and 1. If the AI is less than 0.1, speech intelligibility is generally low. If it is above 0.6, speech intelligibility is generally high.

Artificial Ear

A device used to provide an acoustic coupling between an earphone and a microphone, thus enabling the earphone to be calibrated. The acoustic impedance of the device is made to simulate that of the average human ear. Used to calibrate air conduction audiometers. See also Ear Simulator.

Artificial Mastoid

A device used to load a bone vibrator, dynamically and statically, enabling the bone vibrator to be calibrated. The device includes a mechanical-electrical transducer (usually piezoelectric). The mechanical impedance of the device is made to simulate that of the average human mastoid. Used to calibrate bone conduction audiometers and to test bone conduction hearing aids.

Artificial Reverberation

Reverberation generated by electrical or acoustical means to simulate that of concert halls, etc., Added to a signal to make it sound more lifelike.

ASA

Acoustical Society of America.

Asper

The unit of measurement for roughness. 1 asper is the roughness of a 60 dB, 1 kHz signal with 100% modulation at 70 Hz. See also *Roughness*.

Asymmetrical Support

A rotor support system that does not provide uniform restraint in all radial directions. This is typical in industrial machinery where stiffness in one plane may be substantially different than stiffness in the perpendicular plane. Occurs in bearings by design, or from pre-loads such as gravity or misalignment.

Asynchronous

Frequencies in a vibration spectrum that exceed shaft turning speed (TS), but are not integer or harmonic multiples of TS. Also commonly referred to as non-synchronous.

Attack

The beginning of a sound; the initial transient of a musical note.

Attenuate

To reduce the level of:

- an electrical or acoustical signal
- transmitted sound power or its electrical equivalent
- sound intensity by various means (for example, air, humidity, porous materials, etc.)
- sound level per unit distance by divergence, diffusion, absorption, or scattering

Attenuator

A device, usually a variable resistance, used to control the level of an electrical signal.

Attitude Angle

The angle between the steady state pre-load through the bearing centreline, and a line drawn between the bearing centre and the shaft centreline (applies to fluid film bearings).

Audibility Threshold

The minimum effective sound pressure level of a signal at a specified frequency that is capable of evoking an auditory sensation in a specified fraction of trials.

Audio Frequency

The frequency of oscillation of an audible sound wave, or of an acoustical or electrical signal that falls within the audible range of the human ear, usually taken as 20 Hz to 20 kHz.

Audio Spectrum

See Audio Frequency.

Audiogram

A graph showing individual hearing acuity as a function of frequency.

Audiometer

An electrical instrument, equipped (for air conduction) with two earphones and a headset that provides pure tones of known frequencies of adjustable intensity, used to determine hearing threshold levels, one ear at a time. For bone conduction, the audiometer is also equipped with a bone vibrator. A clinical audiometer includes both facilities as well as a means of generating calibrated masking noise, and usually an input for speech audiometry. In the industrial context, only the air conduction facility is normally required or provided. There are manual audiometers in which the tone presentations and the noting of the subject's responses are performed manually, and self-recording audiometers in which the tone presentation and the recording of the subject's responses are implemented automatically. In the industrial context, a self-recording audiometer is set to present pulsed tones of discrete frequencies, varied in level at a fixed rate. In the clinical context, it may have both pulsed and continuous tone outputs and continuously variable (sweep) frequency.

Audiometric Zero

see Reference zero. The terms are synonymous.

Audiometry

Measurement of auditory function. Pure-tone audiometry means determination of a person's hearing threshold levels for pure tones by air conduction under monaural earphone listening conditions, or by bone conduction. See also Speech audiometry.

Auditory Area

The sensory area lying between the Threshold of Hearing and the Threshold of Pain or feeling.

Auditory Cortex

The region of the brain receiving nerve impulses from the ear.

Auditory System

The human hearing system made up of the external ear, the middle ear, the inner ear, the nerve pathways, and the brain.

Aural

Having to do with the auditory mechanism.

Aures Sharpness Calculation

A correction applied to the Zwicker formula that gives improved level independence.

Auto Correlation

Auto correlation is a time-domain function that is a measure of how much a signal shape, or waveform, resembles a delayed version of itself. It is closely related to the Cepstrum. The numerical value of auto correlation can vary between zero and one. A periodic signal such as a sine wave has an auto correlation that is equal to one at zero time delay, minus one at a time delay of one-half the period of the wave, and one at a time delay of one period; in other words, it is a sinusoidal waveform itself. Wideband random noise has an auto correlation of one at zero delay, but is essentially zero at all other delays. Auto correlation is sometimes used to extract periodic signals from noise.

Autorange

In an autorange, the measurement system detects the maximum input value on the input channels and sets the attenuator (dynamic range) to suit. Used before a calibration or measurement.

Autoscale

In autoscaling, the axes of the graph used to display time signal, spectra, post-processed functions, etc., are automatically set by the software to fit the full display (complete spectrum or signal) into the available viewing area. Dependent on application, it is possible to autoscale to the input range of a measurement, the maximum measured value or a “nice” round number.

Autospectrum

For FFT measurements, the Fourier Transform of a time signal is complex as it has magnitude and phase. The autospectrum is the average of the squared magnitude. For 1/n-octave CPB measurements, it is the mean square of the filter output.

Averaging

When performing spectrum analysis, some form of time averaging must be done to accurately determine the level of the signal at each frequency (unless a transient can be captured). In vibration analysis, the most important type of averaging is linear spectrum averaging, where a series of individual spectra are added together and the sum is divided by the number of spectra. Averaging is very important when performing spectrum analysis of any signal that changes with time, as is usually the case with vibration signals of machinery. Linear averaging smoothes out random noise components in a spectrum, thus making the discrete frequency components easier to see. Another type of averaging that is important in machinery monitoring is time domain averaging, or time synchronous averaging, and it requires a tachometer connected to the trigger input of the analyzer to synchronise each “snapshot” of the signal to the running speed of the machine. Time domain averaging is very useful in reducing the random noise components in a spectrum, or in reducing the effect of other interfering signals such as components from a nearby machine. See also Order Analysis.

Axial

In the same direction as the shaft centreline.

Axial Float (or End Float)

Movement of one shaft along its centreline due to the freedom of movement permitted by a journal bearing or a sleeve bearing. This adjustment should be set before performing vertical or horizontal moves. The degree of axial float can be adjusted by the position of the stops, or whatever limits the motion.

Axial Mode

The room resonances associated with each pair of parallel walls in a rectangular room.

Background Noise

The total of all noise in a system or situation, independent of the presence of the desired signal. In acoustical measurements, strictly speaking, the term “background noise” means electrical noise in the measurement system. However, in popular usage the term “background noise” is often used to mean the noise in the environment (airborne, structure borne, and instrument noise), other than the noise from the source of interest, otherwise known as Residual Noise.

Background Noise Level

The noise level in the acoustic environment, normally excluding the noise source(s) of interest. Alternatively, the value of a noise parameter, such as L_{A90} (the level exceeded for 90% of the measurement time).

Backlash

A condition where a rotor can rotate freely for a certain angular distance before encountering any resisting force. It may be measured in degrees. This term normally applies to couplings and gears.

Backup

To make a copy of data for storage or in case of the risk of data being lost.

Baffle

A movable barrier used in the recording studio to achieve separation of signals from different sources. The surface or board upon which a loudspeaker is mounted.

Band

Any segment of the frequency spectrum.

Band Pass Filter

A filter that has a single transmission band extending from a lower cut-off frequency greater than zero to a finite upper cut-off frequency. Outside the filter bandwidth, the signal is attenuated: the further outside, the greater the attenuation.

Bandwidth

A frequency interval with an upper and lower limit and including all frequencies within this range. A specified band in which (ideally) all components within this band pass completely at full power and all components at other frequencies are attenuated completely. The frequency range passed by a given device or structure.

Bandwidth (-3 dB)

The spacing between the frequencies at which a filter attenuates by 3 dB. Normally expressed as frequency difference for constant bandwidth filters and as percent of centre frequency for constant percentage bandwidth filters.

Bandwidth (Effective Noise)

The bandwidth of an ideal filter that would pass the same amount of power from a white noise source as the filter described. Used to define bandwidth of third-octave and octave filters.

Bark

The unit for the critical band frequency scale (1 – 24 Bark covers the frequency range from 0 – 15500 Hz).

Baseband

The band in which signals are measured when no zooming is applied, that is, from 0 Hz up to X Hz, where X is a value greater than zero and can be up to the maximum frequency value of the input module.

Basilar Membrane

A membrane inside the cochlea that vibrates in response to sound, exciting the hair cells.

Bass

The lower range of audible frequencies.

Bass Boost

The increase in level of the lower range of frequencies, usually achieved by electrical circuits.

Baud Rate

The transmission rate, in data bits per second.

Bearing

There are primarily two types, rolling element and sleeve or plain bearing. Rolling element bearings consist of four parts: an inner race, an outer race, balls or rollers, and a cage to maintain the proper separation of the rolling elements. A sleeve bearing is a cylinder of alloy metal surrounding the rotating shaft. A lubricating film prevents contact between the shaft and the sleeve.

Bearing Frequencies

Faults in any of the bearing components will generate specific frequencies dependent upon the bearing geometry and rotating speed.

Bearing Misalignment

A misalignment that results when the bearings supporting a shaft are not aligned with each other. The bearings may not be mounted in parallel planes, cocked relative to the shaft, or distorted due to foundation settling or thermal growth.

Bearing Nomenclature

Each bearing manufacturer has specific codes applied as prefixes and suffixes to their bearings. These codes inform the user of the construction, materials, clearances, and other factors used in the construction of the bearing. Consult the individual manufacturer’s handbook for specific code meaning.

Beat Frequency

If two vibration components are quite close together in frequency and if they are present at the same time at the same place, they will combine in such a way that their sum will vary in level up and down at a rate equal to the difference in frequency between the two components. This phenomenon is known as beating, and its frequency is the beat frequency. There is confusion in some areas between beating and amplitude modulation, which also can produce an undulating vibration level. Amplitude modulation is different from beating, and is caused by a high-frequency component being multiplied by a lower-frequency component and is thus a non-linear effect, whereas beating is simply a linear addition of two components whose frequencies are close to one another.

Beats

Periodic fluctuations that are heard when sounds of slightly different frequencies are superimposed.

Bi-directional

Data can be transferred in both directions, that is, both transmitted and received.

Binaural Loudness

In a real sound field, the signals at the two ears of a listener often differ from one another, the stimulation of the auditory system being dichotic. Dichotic loudness perception has been investigated, but typically using artificial stimuli over headphone playback without spatial information. In a real sound field, where sound signals at the ears of a listener are scattered depending on the sound incidence angle and the individual characteristics of the listener, dichotic loudness has not been fully investigated. In studies performed at the Sound Quality Research Unit at Aalborg in 2005, a binaural loudness model was developed that enables loudness prediction for any sound field where diotic and dichotic at-ear signals are used as inputs and sound incidence angle does not play a role. The Binaural loudness model makes no assumptions about the sound field for the user, everything is taken care of by the at-ear signals. In this model for any inputs to the left and right ears, a corresponding frontal sound pressure is determined for each frequency band producing equal loudness.

Binaural Recording

Recording sound using two microphones to preserve the directional characteristics of the sound, binaural recording is not the same as stereo recording. A typical binaural recording unit has two microphones mounted in a dummy head, inset in ear-shaped moulds to capture all he adjustments (known as Head Related Transfer Function (HRTF) in psychoacoustic research) that happen naturally as sound wraps around the head and is “shaped” by the form of the outer and inner ear.

Bins

In an FFT spectrum, the individual frequencies at which the amplitudes are calculated, commonly called “lines”. The binwidth equals the frequency span divided by the number of lines. Effective binwidth equals the binwidth times the window noise factor.

Bit

Short for binary digit. A number expressed in binary notation utilises the digits 1 and 0, and these are called bits. Any number can be expressed with combinations of them.

Bode Plot

The frequency response function is actually a three-dimensional quantity, consisting of amplitude vs. phase vs. frequency. Therefore a true plot of it requires three dimensions, and this is difficult to represent on paper. One way to do it is the so-called Bode plot, which consists of two curves, one of amplitude vs. frequency and one of phase vs. frequency. Another way to look at the frequency response function is to resolve the phase portion into two orthogonal components, one in-phase part (called the real part), and one part 90 degrees out of phase (called the quadrature or imaginary part). Sometimes these two phase parts are plotted against each other, and the result is the so-called Nyquist Plot.

Bone Vibrator

An electro-mechanical transducer applied, usually, to the mastoid process.

Boomy

Colloquial expression for excessive bass response in a recording, playback, or sound-reinforcing system.

Bow

A shaft condition such that the geometric centreline of the shaft is not straight.

Bow-tie Correction

Multispectra measurements for correlation functions are performed using spectrum averaging. Half of the normal time record is set to zero. Accordingly, correlation functions for continuous signals will decrease with the delay. The bow-tie correction compensates for this.

Broadband Noise

Noise with components over a wide range of frequencies.

Buffer

A memory location in a computer or digital instrument that is set aside for temporary storage of digital information while it is waiting to be processed.

Bump Testing

A single-channel approximation to a two-channel impact test. This method works because the impacting force approximates an impulse and imparts broadband excitation over a limited frequency range. Since the Fourier Transform of the impulse response function is the frequency response function, it provides a good method of estimating the natural frequencies of a structure.

Byte

A term used in digital systems. Equal to 8 bits of data. See Bit.

Calculated Peak

Term used to describe the spectral overall RMS level multiplied by $\sqrt{2}$. Sometimes referred to as “derived peak” or “pseudo peak”.

Calibration

The process of measuring to determine the accuracy of your measurement chain. This result can then be used to offset measured values and take account of this inaccuracy.

Calibrator

A device that produces a known sound pressure on a microphone in a sound level measurement system, or a known vibration (acceleration, velocity, or displacement) on an accelerometer in a vibration measurement system. It is used to adjust the system to standard specifications.

Campbell Diagram

A graph which shows frequency on axis and machine RPM on the horizontal axis. The spectral amplitude is indicated by the diameter of a circle (or the side length of a square) at each point in the diagram.

Capacitor

An electrical component that passes alternating currents but blocks direct currents. Also called a condenser, it is capable of storing electrical energy.

CCLD

Constant current line drive, as used by DeltaTron® accelerometers and microphone preamplifiers.

Centre Frequency

The arithmetic centre of a constant bandwidth filter, or the geometric centre (midpoint on a logarithmic scale) of a constant percentage bandwidth filter. When specifying an FFT zoom frequency span, the centre frequency is the middle point of the frequency span that you want to analyse. For example, if measuring a 2 kHz zoom frequency span and the centre frequency is 6 kHz, the measured range is from 5 kHz to 7 kHz.

Cepstrum

The cepstrum is the forward Fourier transform of the logarithm of a spectrum. It is thus the spectrum of a spectrum, and has certain properties that make it useful in many types of signal analysis. One of its more powerful attributes is the fact that any periodicities, or repeated patterns, in a spectrum will be sensed as one or two specific components in the cepstrum. If a spectrum contains several sets of sidebands or harmonic series, they can be confusing because of overlap. But in the cepstrum, they will be separated in a way similar to the way the spectrum separates repetitive time patterns in the waveform. Gearboxes and rolling element bearing vibrations lend themselves especially well to cepstrum analysis. The cepstrum is closely related to the auto correlation function.

Characteristic Equation

The mathematical equation whose solution defines the dynamic characteristics of the structure in terms of its natural frequencies, damping, and mode shapes. The mathematical formulation of the characteristic equation is called the Eigenvalue problem. The characteristic equation is obtained from the equations of motion for the structure.

Charge Amplifier

An amplifier with low input impedance whose output voltage is proportional to the output charge from a piezoelectric transducer. Has the advantage that voltage output is not affected by length of connecting cable from the transducer.

CIC

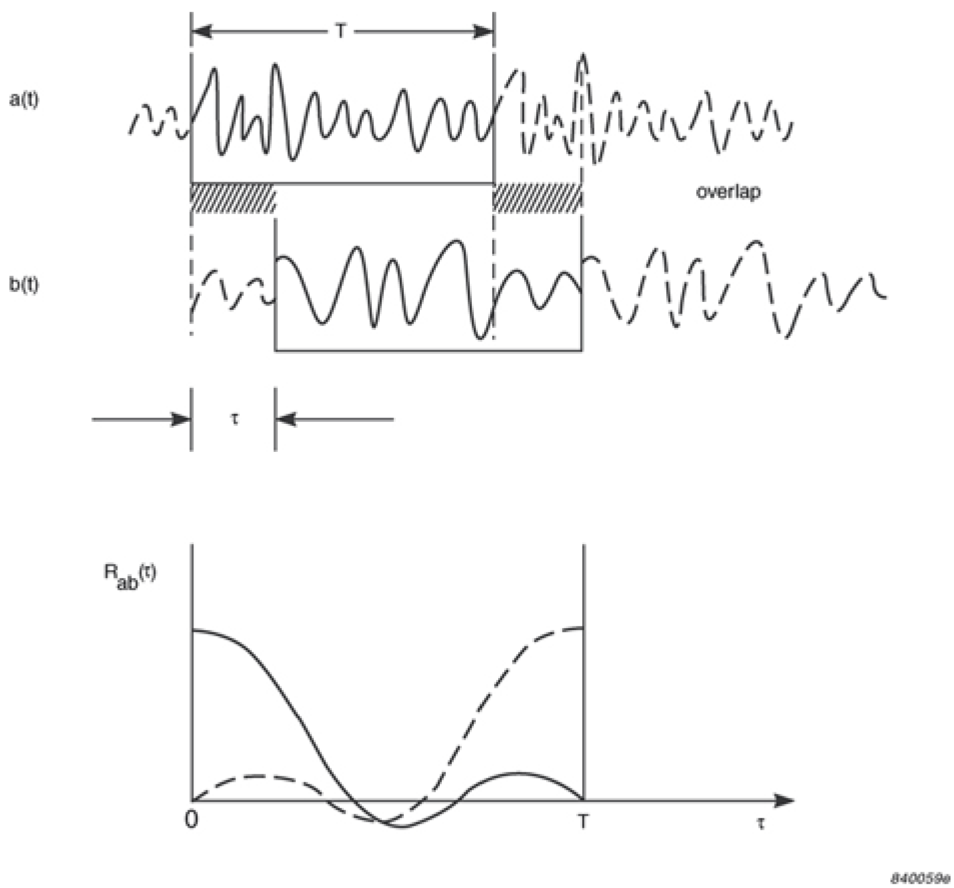
Charge Injection Calibration (CIC) is a technique patented by Brüel & Kjær for on-line verification of the integrity of the entire measurement chain, for example, microphone, preamplifier and cabling. Even microphones remote from the input stage/conditioning amplifier can be verified. The basic philosophy behind CIC is that if we have a known condition (for example, a properly calibrated microphone) and establish a reference measurement, then as long as the reference value does not change, nothing has changed, for example, the microphone calibration will still be valid. Additionally CIC verifies the cable and preamplifier.

Circle Fit

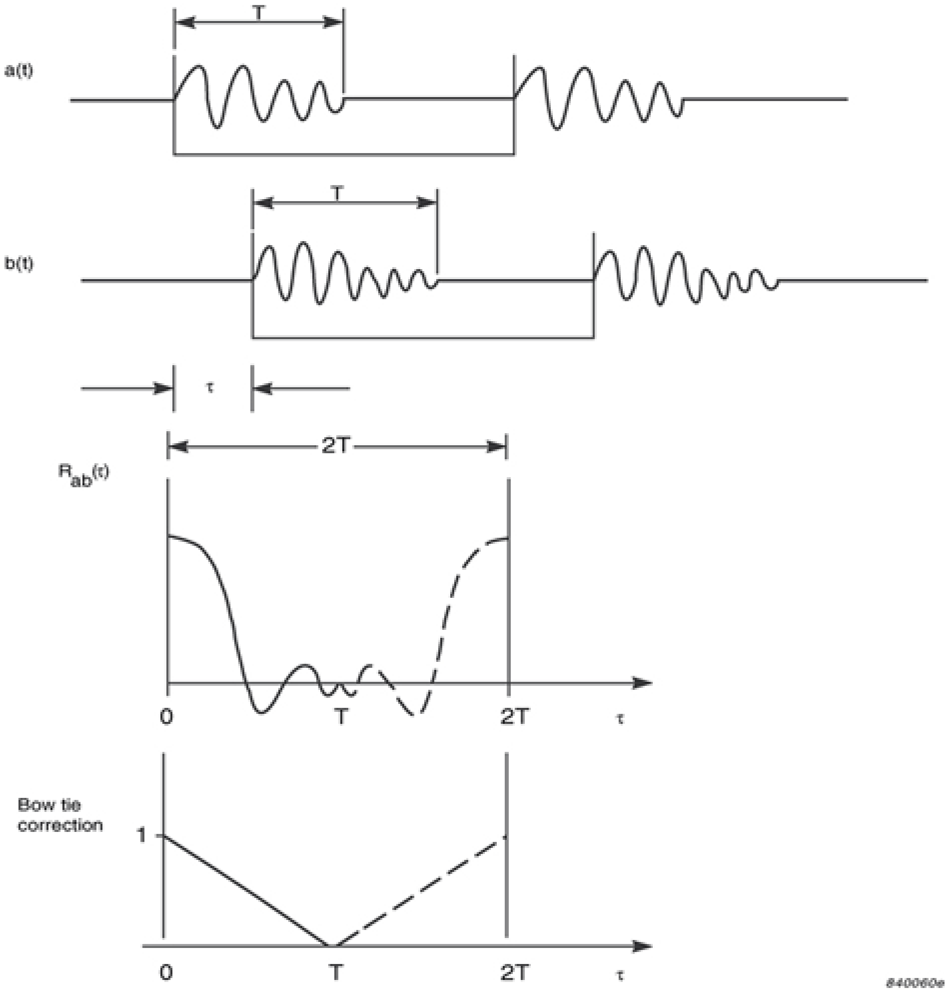
A single degree of freedom curve-fitting routine that tries to fit a mode to a circle (Nyquist plot of a single degree of freedom system). The modal coefficient is determined by the diameter of the circle and the phase by its location relative to the imaginary axis. For a real mode, it should be either completely above or completely below the imaginary axis.

Circular Correlation Effect

When using FFT to calculate auto- or cross-correlation from auto- or cross-spectra, rectangular weighting is used so that the signal is not distorted. This introduces leakage, which affects both the spectra and the correlation functions. Due to the discrete Fourier transform, the analyzer treats the signal as periodic. When correlation functions are calculated from such signals, there is a contribution from the end of one period multiplied by the beginning of the next. This is called the circular correlation effect:



To avoid this effect, zero pad is used. This also introduces an error into the calculations, but as the error is the same for all signals it can be compensated for using the bow-tie correction:



Further information can be found in *Brüel & Kjær Technical Review, No. 2, 1984, p.29*.

Classical Damping (in structural dynamics)

It is assumed that the damping matrix may be expressed as a linear combination of the mass matrix and the stiffness matrix.

Clipping

An electrical signal is clipped if the signal level exceeds the capabilities of the amplifier. It is a distortion of the signal.

Coast-down

The slowing down of a rotating or reciprocating machine where no braking is applied.

Cochlea

A spirally coiled organ located within the inner ear that contains the receptor organs essential to hearing. Its hair cells respond to pressure fluctuations caused by mechanical vibrations of the cochlea fluid and generate nerve impulses that are interpreted by the brain as sound. It is the frequency-analysing portion of the auditory system.

Coefficient of Determination

An indicator of how well the equation resulting from regression analysis explains the relationship among the variables. It is obtained by comparing estimated and actual preference. It ranges in value from 0 to 1, where "1", represents perfect correlation in the sample (that is, there is no difference between the estimated y-value and the actual y-value) and "0" represents no correlation (that is, the regression equation is not helpful in predicting a y-value). Used in Brüel & Kjær's Psychoacoustic Test Bench program, BZ 5301

Coherence

Coherence is a number between one and zero, and is a measure of the degree of linearity between two related signals, such as the excitation force (input) of a structure related to the vibration response to that force (output). Coherence is thus a two-channel measurement, and does not apply to single-channel measurements of vibration signatures. In a frequency response measurement of a mechanical structure, if the structure is linear, the coherence will be one (100% coherent), but if there is some non-linearity in the structure, if there is noise in a measurement channel, or if the impulse response is truncated by the analysis (if the frequency resolution is inadequate) the coherence will be less than one. A dual-channel FFT analyzer is able to measure the coherence between the two channels, and it is a useful tool in determining good from noisy or meaningless data.

Coherent Power

If the signal-to-noise ratio is high, it is equal to the product of the coherence and the measured output power spectrum. Useful for determining the contributions of sources in a measured signal that is made up of a number of sources.

Cold Alignment

Machine condition in which alignment procedures are normally performed. Changes in off-line to on-line running conditions should be allowed for during this procedure so that the machine can "grow" into alignment during operation. Also known as static alignment or primary alignment.

Coloration

The distortion of a signal detectable by the ear.

Comb Filter

A distortion produced by combining an electrical or acoustical signal with a delayed replica of itself. The result is constructive and destructive interference that results in peaks and nulls being introduced into the frequency response. When plotted to a linear frequency scale, the response resembles a comb, hence the name.

Combination Metric

A new objective metric created as a weighted sum of a number of single metrics. Can be created using Brüel & Kjær's Psychoacoustic Test Bench tool BZ5301.

Common-mode Rejection

A measure of a measurement systems capability of rejecting common-mode signals.

Common-mode Signals

Signals of identical magnitude and phase that appear simultaneously at two inputs of an amplifier.

Common-mode Voltage

The voltage arising from common-mode signals.

Complex Acoustic Admittance

The ratio of the sound particle velocity through the surface to the surface sound pressure.

Complex Acoustic Impedance

The ratio of the surface sound pressure to the sound particle velocity through the surface.

Complex Intensity

Complex intensity is the combined real intensity and imaginary intensity.

Complex Modes

The points on a structure have varying phase relationships between them at a natural frequency. This is unlike a real mode where the phase between points is either 0° or 180°.

Complex Reflection Coefficient

The complex ratio of the pressure of the reflected wave to the pressure of the incident wave.

Complex Spectrum

In a Complex or Fourier spectrum, the lines in the spectrum resulting from FFT analysis are equidistant, so the time signal is analysed in constant bandwidths. The analyzer analyses the time signal in blocks and each block is recorded in memory and a Fast Fourier Transform (FFT) is performed on each block. See also FFT Analysis.

Complex Time

This is the analytical time signal where the real part is the time signal itself. The imaginary part is the Hilbert transform of the real part. The magnitude of the complex time signal is the envelope of the real signal.

Compliance

Frequency response function of displacement/force – the ease with which a system may be displaced or compressed for a given force. The reciprocal of Stiffness. Also known as Dynamic Compliance. See also Immittance.

Compression

Reducing the dynamic range of a signal by electrical circuits that reduce the level of loud passages.

Condenser

A Capacitor.

Conductive Hearing Loss

Hearing loss caused by blockage of the outer ear or by derangement of the middle ear.

Constant Bandwidth Analysis

Analysis using Constant Bandwidth Filters. This gives a uniform frequency resolution on a linear frequency scale.

Constant Bandwidth Filter

A filter with fixed frequency bandwidth, expressed in hertz (Hz), regardless of centre frequency.

Constant Percentage Bandwidth

see CPB.

Constant Percentage Filter

A filter whose bandwidth is a fixed percentage of centre frequency. The width of the individual filters is defined relative to their position in the range of interest. The higher the centre frequency of the filter, the higher the bandwidth. The bandwidth is defined in octaves or as a fixed percentage of the centre frequency of the filter.

Continuous Sound

Sound having a steady nature that is not impulsive.

Contour Graph

A graph that plots all point values and links together all points that belong within a band or level. Each of these levels is then shown in a unique colour. It divides all points into groups of closed curves. Every curve links together all points in the group that possess the same data value.

Contribution

Part of the total sound that comes to a particular receiver in a vehicle's interior from one or several sources

Control System

A system in which deliberate guidance or manipulation is used to achieve a prescribed value of a variable.

Correlogram

A graph showing the correlation of one signal with another.

Cortex

see Auditory Cortex.

Cosine Taper

Attenuation by a numerical factor that varies with time as a cosine function.

Coulomb Damping

Non-linear damping that is a result of rubbing, looseness, etc.

Coupling

Mechanical fixture for joining two shafts. See also Signal Ground Coupling.

CPB

Constant Percentage Bandwidth (analysis); the width of the filters is defined relative to their position in the frequency range of interest. The higher the centre frequency of the filter, the higher the bandwidth. The bandwidth is defined in octaves, or as a fixed percentage of the centre frequency of the filter. A typical CPB analysis uses 1/3-octave filters, which correspond to 23% of the centre frequency.

Crest Factor

The term used to represent the ratio of the peak (crest) value to the rms value of a waveform. For example, a sine wave has a crest factor of 1.4 (or 3 dB), since the peak value equals 1.414 times the rms value. Music has a wide crest factor range of 4 – 10 (or 12 – 20 dB). This means that music peaks occur 12 – 20 dB higher than the rms value, which is why headroom is so important in audio design.

Critical Band

In human hearing, only those frequency components within a narrow band, called the critical band, will mask a given tone. Critical bandwidth varies with frequency but is usually between 1/6- and 1/3-octave. The ears act like a set of parallel filters, each with its own bandwidth. 24 critical bands make up the frequency range from 20 Hz to 16 kHz. Critical bands are approximated by 1/3-octave bands above 500 Hz and by 100 Hz wide bands at lower frequencies.

Critical Damping

The minimum viscous damping that will allow a displaced system to return to its original position without oscillation.

Cross Correlation

Cross correlation is a measure of the similarity of two time domain signals. If the signals are identical, the cross correlation will be one, and if they are completely dissimilar, the cross correlation will be zero.

Cross-spectrum

The cross-spectrum is the forward Fourier transform of the cross-correlation function. Generally, the cross-spectrum is a complex function.

Cross-talk

The signal of one channel, track, or circuit interfering with another.

Crossover Frequency

In a loudspeaker with multiple radiators, the crossover frequency is the –3 dB point of the network dividing the signal energy.

Cumulative Distribution

A method of representing time-varying noise by indicating the percentage of time that the noise level is present above (or below) a series of amplitude levels.

Cursor

A thin hairline that can be displayed and positioned on spectrum or time signal graphs to obtain a readout. Various types of cursor are available. For example, single cursor – a line, delta cursor – selects a band, harmonic cursor – marks a set of harmonics.

Cursor Handles

Points on a movable cursor that can be selected by the mouse and then dragged to a chosen position.

Cursor Readings

Information that can be read out from displayed functions when interrogated using cursors.

Curve Fit

The process of fitting a curve to a set of polynomials.

Cut-off Frequency

The frequencies that mark the ends of a band, or the points at which the characteristics of a filter change from pass to no-pass.

Cycle

The complete sequence of values of a periodic quantity that occurs during one period.

Cycles Per Second

A measure of frequency numerically equivalent to hertz (Hz).

Cylindrical Wave

A wave in which the surfaces of constant phase are coaxial cylinders. A line of closely spaced sound sources radiating into an open space produces a free sound field of cylindrical waves.

Daily Acoustic Immission (DAI)

See Sound Exposure Level.

Damped Natural Frequency

The damped natural frequency is the frequency at which a damped system will oscillate in a free vibration situation.

Damping

Any means of dissipating vibration energy within a vibrating system.

- The dissipation of energy with time or distance. The term is generally applied to the attenuation of sound in a structure owing to the internal sound-dissipative properties of the structure or to the addition of sound-dissipative materials.
- The action of frictional or dissipative forces on a dynamic system causing the system to lose energy and reduce the amplitude of movement.
- Removal of echoes and reverberation by the use of sound absorbing materials. See also Reverberation Time.

Damping Ratio

Ratio of actual damping to Critical Damping, at a resonant frequency. Also, the ratio of the decrease in signal amplitude as a function of time.

DAT Recorder

Digital audio tape recorder.

Data Source

The identity and location of the data that are used in an analysis.

Day-Night Average Sound Level (Ldn)

A-weighted equivalent continuous sound exposure level for a 24-hour period with a 10 dB adjustment added to the sound levels occurring during nighttime hours (10 p.m. to 7 a.m.).

dB

decibel. A bel (after Alexander Graham Bell) is defined as the logarithm to base ten of the ratio of two acoustical powers, or intensities. One tenth of a bel, the decibel, is the generally used unit. See Decibel.

dB(B)

A sound-level meter reading with a B-weighting network simulating the human-ear response at a loudness level of 70 phons.

dB(C)

A sound-level meter reading with C-weighting network simulating the human-ear response at a loudness level of 100 phons.

dBA, dB(A)

A sound-level meter reading with an A-weighting network simulating the human-ear response at a loudness level of 40 phons. The weighting is specified in ANSI Specifications for Sound Level Meter, S1.4-1983

DC Coupling

The connection of a signal from one circuit to another in a manner that passes both AC and DC components. See also AC Coupling.

DC Offset

The change in input voltage required to produce zero output voltage when no signal is applied to an amplifier.

Decade

Ten times any quantity or frequency range. The range of the human ear is about 3 decades.

Decay Rate

A measure of the decay of acoustical signals, expressed as a slope in dB/second. The rate at which a signal drops off.

Decibel (dB)

The primary unit of sound measurement; used to quantify both sound pressure level and sound power level. Used for measuring the relative magnitude based on a logarithmic scale. See dB and Sound Pressure Level.

Decibel Formulae

Quantity	Symbol	Formula	Ref. Level*
Sound Pressure Level	L_p	$20 \log(p/p_0)$ dB	20 mPa (in air) 1 mPa (in water)
Acceleration Level	L_a	$20 \log(a/a_0)$ dB	1 mm/s^2
Velocity Level	L_v	$20 \log(v/v_0)$ dB	1 nm/s
Force Level	L_F	$20 \log(F/F_0)$ dB	1 mN
Power Level	L_W	$10 \log(P/P_0)$ dB	1 pW
Intensity Level	L_I	$10 \log(I/I_0)$ dB	1 pW/m^2
Energy Density Level	L_w	$10 \log(w/w_0)$ dB	1 pJ/m^3
Energy Level	L_E	$10 \log(E/E_0)$ dB	1 pJ
* p_0, a_0, etc.			

Decibel Scale

A linear numbering scale used to define a logarithmic amplitude scale, thereby compressing a wide range of amplitude values to a small set of numbers.

Degree of Freedom

In a mechanical system, equals the minimum number of independent co-ordinates required to completely define the position of all parts of the system at any instant of time. Refers to a point and a direction in which a structure vibrates, or in which the vibration is measured.

Delay

An entered time difference that has to elapse after (or before) triggering of a measurement and sampling of the time history data begins. There are situations where entering a trigger delay is useful.

Delay Compensation

Compensation for the delay on the finite detector response time on a swept frequency analysis compared with the true result, which would be achieved with an infinitely slow rate of sweep.

Delay Line

A digital, analog, or mechanical device employed to delay one audio signal with respect to another.

Detector

An electronic circuit that determines the amplitude level of a signal in accordance with certain rules. The simplest type of detector consists of a resistor and a capacitor, and it measures the rectified average value of a fluctuating DC signal. A more complex, but much more useful type of detector is an RMS detector whose output is proportional to the power or energy present in the signal or a vibration.

Deterministic

A type of signal whose spectrum consists of a collection of discrete components, as opposed to a random signal, whose spectrum is spread out or “smeared” in frequency. Some deterministic signals are periodic, and their spectra consist of harmonic series. Vibration signatures of machines are in general deterministic, containing one or more harmonic series, but they always have non-deterministic components, such as background noise. See also Stationary Signals. Transients can also be deterministic.

DFCF

Diffuse field correction filter.

DHCP

Dynamic Host Configuration Protocol.

Diaphragm

Any surface that vibrates in response to sound or is vibrated to emit sound, such as in microphones and loudspeakers. Also applied to wall and floor surfaces vibrating in response to sound or in transmitting sound.

Dielectric

An insulating material. The material between the plates of a capacitor.

Differentiation

In vibration analysis, differentiation is a mathematical operation that converts a displacement signature to a velocity signature, or a velocity signature to an acceleration signature. It is performed electronically on an analog signal or can be performed digitally on a spectrum. Differentiation is an inherently noisy operation, if performed on an analog signal, adding a significant amount of high-frequency noise to the signal, and is generally not used very much in machinery vibration analysis. It is not inherently noisy if it is done digitally on the FFT spectrum. See also Integration, which is the inverse of differentiation.

Diffraction

The distortion of a wave front caused by the presence of an obstacle in the sound field. The scattering of radiation at an object smaller than one wavelength and the subsequent interference of the scattered wave fronts.

Diffuse Field

A sound field in which the sound pressure level is the same everywhere and the flow of energy is equally probable in all directions.

Diffuse Sound

Sound that is completely random in phase; sound that appears to have no single source.

Diffusion

The act of sound waves spreading out over a wide area, reflecting off a convex or other uneven surface.

Diffusor

(Diffuser) A proprietary device for the diffusion of sound through reflection-phase-grating means.

Digital

Digital instrumentation consists of devices that convert analog signals into a series of numbers through a sampling process and an analog to digital converter. They then perform operations on the numbers to achieve such effects as equalisation, data storage, data compression, frequency analysis, etc. This process in general is called digital signal processing. It is characterised by several advantages and disadvantages. One advantage is that the converted signals can be manipulated, transformed and copied without introducing any added noise or distortion. The disadvantage is that the signal representation may not be truly representative of the original signal. Digital signal processing requires analog to digital (A/D) conversion of the input signal. The first step in A/D conversion is sampling of the instantaneous amplitudes of the signal at specific times determined by the sampling rate. If the signal contains any information at frequencies above one-half the sampling frequency, the signal will not be sampled correctly, and the sampled version of the signal will contain spurious components. This is called aliasing. The theoretical maximum frequency that can be correctly sampled is equal to one-half the sampling rate, and is called the Nyquist frequency. In all digital signal processing systems, including FFT analyzers, the sampling rate is made to be significantly greater than twice the highest frequency present in the signal in order to be certain the aliasing will not occur.

Digital Filter

A digital processor that receives a sequence of input data values, executes an operation on them, and outputs a corresponding sequence of values that have been filtered with respect to the input.

Digital Filter Analyzer

Uses constant percentage (or relative) bandwidth resolution. This is often preferred for acoustic measurements because it best simulates the way in which the human ear perceives sound.

Digital Signal Processing (DSP)

DSP is the analysis of digital signal data. The original analog signal is sampled at regular time intervals, and an Anolog to Digital converter converts the sampled amplitudes into a number series.

Dimensionless Frequency Domain Functions

see Coherence.

Dimensionless Time Domain Functions

see Auto correlation.

Direct Field

The region in which the sound measured can be attributed to the source alone without the effects of obstructions, walls, etc.

Directivity Factor

The ratio of the mean-square pressure (or intensity) on the axis of a transducer at a certain distance to the mean-square pressure (or intensity) that a spherical source radiating the same power would produce at that point.

Directivity Index

In a given direction from a sound source, the difference in decibels between (a) the sound pressure level produced by the source in that direction, and (b) the space-average sound pressure level of that source, measured at the same distance.

Directivity Pattern

A graphical description, usually in polar co-ordinates, of the response of the transducer as a function of the direction of the transmitted or incident sound waves in a specified plane and at a specified frequency.

Discrete

With reference to a spectrum, discrete means consisting of separate distinct points, rather than continuous. An example of a discrete spectrum is a harmonic series. An FFT spectrum, which consists of information only at specific frequencies (the FFT lines), is actually discrete regardless of the input signal. For instance, the true spectrum of a transient is continuous, and the FFT of a transient appears continuous on the screen, but still only contains information at the frequencies of the FFT lines. The input signal to an FFT analyzer is continuous, but the sampling process necessary to implement the FFT algorithm converts it into a discrete form, with information only at the specific sampled times.

Discrete Fourier Transform

The mathematical calculation that converts or “transforms” a sampled and digitised waveform into a sampled spectrum. The fast Fourier transform, or FFT, is an algorithm that allows a computer to calculate the discrete Fourier transform very quickly. See also Fast Fourier Transform.

Discrimination Score

See Speech Audiometry.

Displacement

A vector quantity that specifies the change of position of a body. Usually measured from the rest position.

Displacement, Velocity, Acceleration Relationships

(for sinusoidal motion only)

- d_o = peak displacement
- D = pk-pk displacement
- f = frequency in Hz
- $t = 1/f$ seconds = period in seconds
- $g = 9.80665\ \text{m/s}^2 = 386.09\ \text{in/s}^2 = 32.174\ \text{ft/s}^2$
- G = acceleration in g units

Displacement: $d = d_o \sin 2\pi ft$

Velocity: $v = d_o 2\pi f \cos 2\pi ft$

Acceleration: $a = -d_o (2\pi f)^2 \sin 2\pi ft$

$G = a/g$

$v_o = 6.28\, f\, d_o = 3.14\, f\, D$

$v_o = 61.42 \dfrac{G}{f}$ in/s pk $= 1.560 \dfrac{G}{f}$ m/s pk

$d_o = 9.780 \dfrac{G}{f^2}$ inches pk; or $G = 0.0511\, f^2 D$ (for D in inches pk-pk)

$= 0.2484 \dfrac{G}{f^2}$ metres pk; or $G = 2.013\, f^2 D$ (for D in metres pk-pk)

Distance Double Law

In pure spherical divergence of sound from a point source in free space, the sound pressure level decreases 6 dB for each doubling of the distance. This condition is rarely encountered in practice, but it is a handy rule to remember in estimating sound changes with distance.

Distortion

Any change in the waveform or harmonic content of an original signal as it passes through a device. The result of non-linearity within the device.

Distortion, Harmonic

Changing the harmonic content of a signal by passing it through a non-linear device.

Dodd Bars

A secondary alignment method. Consists of two bars that are similar in configuration to reverse dial indicator bars. However, these bars are not mounted on the shaft, they are mounted to the machine. Each bar is fitted with a proximity probe and it corresponds to a block on the other bar. As the machines move to their on-line condition the gap between the proximity probes and the metal blocks changes, which changes the voltages. The analyzer converts the voltages to distances from which the alignment corrections can be calculated.

Domain

A domain is a set of co-ordinates in which a mathematical function resides. A waveform, for instance, has dimensions of amplitude and time, and it is said to exist in the time domain, while a spectrum has dimensions of amplitude and frequency, and is said to exist in the frequency domain.

Doppler Effect (Doppler Shift)

The apparent upward shift in frequency of a sound as a noise source approaches the listener or the apparent downward shift when the noise source recedes. The classic example is the decrease in pitch of a railroad whistle as a locomotive passes by.

Dosimeter

A device worn by a worker for determining the worker's accumulated noise exposure with regard to level and time according to a pre-determined integration formula.

Driving Point Measurement

A frequency response measurement where the excitation point and direction are the same as the response point and direction.

Dynamic Capability (for Sound Intensity)

The dynamic capability of an Intensity measurement system is determined by adding normally 7 or 10 dB (for a measuring error less than 1 or 0.5 dB, respectively) to the pressure-Residual Intensity Index.

Dynamic Compliance

see Compliance.

Dynamic Mass

Ratio of applied force to resulting acceleration during simple harmonic motion.

Dynamic Modulus

Ratio of stress to strain under vibratory conditions.

Dynamic Range

All audio systems are limited by inherent noise at low levels and by overload distortion at high levels. The usable region between these two extremes is the dynamic range of the system. Expressed in dB.

Dynamic Stiffness

The frequency response function of force/displacement.

Dyne

The force that will accelerate a 1 gram mass at the rate of 1 cm/s. The old standard reference level for sound pressure was 0.0002 dyne/cm2. The same level today is expressed as 20 micro pascals, or 20 μPa.

Ear Canal

The external auditory meatus; the canal between the pinna and the eardrum.

Ear Protector

see Hearing Protector.

Ear Simulator

Synonymous with Artificial Ear.

Eardrum

The tympanic membrane located at the end of the ear canal that is attached to the ossicles of the middle ear.

Earmuff

An ear protector consisting of two earcups, each covering the pinna and having a soft ring to be pressed against the head around the pinna.

Earphone

An electroacoustic transducer operating from an electrical system to an acoustical system and designed to be applied to the ear, usually without leakage. See Headphone.

Earplug

An ear protector that is inserted into the ear canal.

Eccentricity, Mechanical

The variation of the outer diameter of a shaft surface when referenced to the true geometric centreline of the shaft. Out-ofroundness.

Eccentricity Ratio

The vector difference between the bearing centreline and the average steady-state journal centreline. Applies to sleeve bearings not anti-friction bearings.

Echo

A delayed return of sound that is perceived by the ear as a discrete sound image. Some signals may contain an echo due to reflection. The time delay associated with the echo may be of interest. For the detection of echoes and measurement of the associated time delay, power cepstra are used.

Echograms

A record of the very early reverberatory decay of sound in a room.

Eddy Current Probe

A non-contact electrical device that measures the displacement of one surface relative to the tip of the probe. Construction consists of an electrical coil of various lengths and diameters. This coil located in the tip of the probe is energised producing an electrical field around the tip of the probe. When a conductive surface is placed in the field and the distance from the probe is noted, variations in this gap can be determined by the variations in the voltage flow to the probe tip.

EES

Early, early sound. Structure-borne sound may reach the microphone in a room before the airborne sound because sound travels faster through the denser materials.

EFC

Energy-frequency curve.

Effective Mass

The frequency response function of force/acceleration.

Effective Noise Bandwidth

The width of an ideal filter with the same transmission level, and which transmits the same power from a white noise source.

EFTC

Energy-frequency-time curve.

Eigenvalue

The roots of the Characteristic Equation.

Eigenvalue Problem

The mathematical formulation and solution of the *Characteristic Equation* is called the Eigenvalue problem.

Eigenvectors

The mode shape vectors.

End Float

see Axial Float.

Engineering Format

The engineering format (Eng.) is used to set up the spectrum values with a metric prefix (...μ, m, k, M...).

Engineering Units, EU

The units in which a measurement is made; for instance velocity may be expressed in millimetres per second, feet per second, miles per hour, etc., depending on the use to which the data will be put. Modern instrumentation allows you to specify what the engineering units are and to apply conversion factors if needed.

Enhanced Spectrum

The Fourier transform of the enhanced time signal. See Enhanced Time.

Enhanced Time

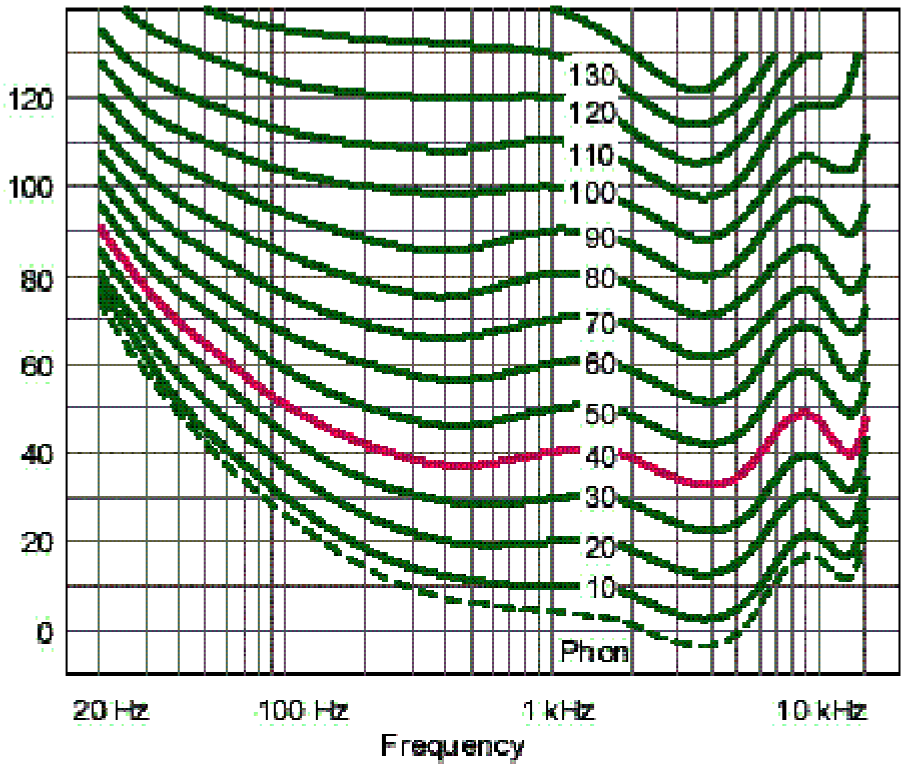
This is an average of the time signal.

Envelope Analysis

Frequency analysis of the envelope of the original time signal. If the original signal is amplitude modulated, the envelope analysis extracts the modulating signal (amplitude demodulation). Envelope analysis is useful for detecting cracks in roller bearings.

Equal Loudness Contour

A contour representing a constant loudness for all audible frequencies. The contour having a sound pressure level of 40 dB at 1000 Hz is arbitrarily defined as the 40-phon contour.



Equalisation

The process of adjusting the frequency response of a device or system to achieve a flat or other desired response.

Equaliser

A device for adjusting the frequency response of a device or system.

Equivalent Continuous A-Weighted Sound Level (LAeq)

The constant sound level that, in a given time period, would convey the same sound energy as the actual time-varying A-weighted sound level.

Equivalent Continuous Sound Pressure Level (Leq)

The notional sound pressure level that would cause the same sound energy to be received as that due to the actual (fluctuating) sound over the same total duration. Sample equivalent continuous sound pressure level (Leq(s)): the value of equivalent continuous sound pressure level (as defined above) measured over a sampling period shorter than the whole duration of the sound.

ESD (Energy Spectral Density)

The energy of a transient as a function of frequency. Energy Spectral Density (ESD) is a scaling unit.

Essinger Bars

A secondary alignment method used to measure the difference between on-line and off-line running conditions. The method measures the change in distance and a change in angle between two tooling balls. One ball is fixed to the bearing and the other ball is fixed to a fixed reference point (usually the floor). The balls are connected by means of an inside micrometer with a resolution of at least 0.001". This should be set up for both sides of the bearing, so the readings can be taken simultaneously. And readings should be taken at every bearing. As the machine “grows” the distances between the balls and the angle between the inside micrometer and a fixed location (also usually the floor) will change. These changes can be used to determine the changes in alignment.

EU

See Engineering Units.

Eustachian Tube

The tube running from the middle ear into the pharynx that equalises middle ear and atmospheric pressure.

Excitation

An external force or motion applied to a system that causes the system to respond in some way.

Experimental Modal Analysis

This is used with a physical structure, typically a prototype of a scale model. See Modal Analysis and Modal Testing.

Exponential

A decaying exponential weighting function, specified by a starting point (shift) and a constant time (length). Use exponential weighting for exponentially decaying transients longer than one time record, to avoid leakage caused by truncation.

Exponential (Response) Window

A special windowing function used in impact testing for minimising leakage in lightly damped structures. In a lightly damped structure, oscillations may not die out within the sampled time data block, T, which results in leakage error. An exponential window adds damping to the time signal to force it to die out within the time T, thus minimising leakage. The added damping is then removed mathematically after the signal is processed.

Exponential Taper

Attenuation by a numerical factor that varies exponentially with time.

External Meatus

The ear canal terminated by the eardrum.

External Sampling

Where time record capture is triggered by an external signal.

Fall-off Rate

The rate at which a signal's amplitude diminishes.

Far Field

Describes a region in free space at a much greater distance from a sound source than the linear dimensions of the source itself where the sound pressure level obeys the inverse-square law (the sound pressure level decreases 6 dB with each doubling of distance from the source). Also, in this region the sound particle velocity is in phase with the sound pressure. Closer to the source, where these two conditions do not hold, constitutes the near field region. In the far field, the sound waves can be considered planar. See also: Diffraction.

Fast Fourier Transform (FFT)

The FFT is an algorithm, or digital calculation routine, that efficiently calculates the Discrete Fourier Transform from the sampled time waveform. In other words it converts, or "transforms", a signal from the time domain into the frequency domain.

Feedback, Acoustic

Unwanted interaction between the output and input of an acoustical system, for example, between the loudspeaker and the microphone of a system.

Feedback Control System

A control system that achieves prescribed relationships between selected system variables by comparing functions of these variables and using the differences to effect control.

FFT

Fast Fourier Transform. Gives the mathematical connection between time and frequency and vice versa and, given a time signal, allows the calculation of its spectrum. An iterative program that computes the Fourier Transform in a shorter time.

FFT Analyzer

An FFT analyzer is a device that uses the FFT algorithm to calculate a spectrum from a time domain signal, and is the most common type of spectrum analyzer available today. The FFT analyzer is a very useful device, and is available in a great variety of models of varying complexity. It is the heart of any machinery predictive maintenance program. An FFT analyzer uses constant (or absolute) bandwidth resolution. This is often preferred in vibration analysis because it gives a better frequency resolution. See also Fast Fourier Transform.

Fidelity

As applied to sound quality, the faithfulness to the original.

Field Impact Insulation Class (FIIC)

A single-number rating for impact sound insulation, calculated from measured values of normalised impact sound pressure levels.

Field STC (FSTC)

Sound Transmission Class based on field measurements of sound transmission loss of a partition.

Filter

A device for separating components of a signal on the basis of their frequency. It allows components in one or more frequency bands to pass relatively unattenuated, and it attenuates components in other frequency bands. Modifies the frequency spectrum of a signal usually while it is in electrical form.

Filter, Bandpass

A filter that passes all frequencies between a low-frequency cut-off point and a high-frequency cut-off point.

Filter, High-pass

A filter that passes all frequencies above a cut-off frequency.

Filter, Low-pass

A filter that passes all frequencies below a cut-off frequency.

Finite Element Analysis or Modelling

A computer-aided design technique for mathematically modelling a structure. Finite element modelling is used for structural analysis, heat transfer analysis, and modal analysis.

Fixed Format

Fixed format numbering is where numbers be entered as their absolute values. The whole number is entered followed by a decimal point, if required, and the required number of significant figures.

Flanging

The term applied to the use of comb filters to obtain special sound effects.

Flanking Path

An indirect sound transmission path, such as the structure-borne path between two adjacent rooms.

Flat Top Window

The flat top window is a special time window with low ripple that is used in some FFT analyzers in addition to the more common Hanning Window and Rectangular Time Window. The flat top window does not allow as fine a frequency resolution as the Hanning window, but it will accurately measure the amplitude level of a signal at any frequency, even if the frequency is between the lines of the FFT analysis. The maximum picket-fence-error is 0.008 dB. It is used in transducer calibration systems to increase amplitude accuracy.

Fluctuation Strength

A measure of the low-frequency (below 20 Hz) amplitude and frequency modulation of sound. It is perceived as changes in the frequency and volume of the sound with time. Fluctuating signals of this type sound louder, and more annoying, than a steady signal of the same RMS magnitude. The effect is most noticeable when the modulation frequency is around 4 Hz.

Flutter

A repetitive echo set up by parallel reflecting surfaces.

Flyover Noise

Measurement of aircraft noise as aircraft fly over.

Force Window

A special windowing function for minimising noise in impact testing. Since the duration of the actual impact is usually very short relative to the overall digitised time sample, the frequency response function of the force signal can have a low signal-to-noise ratio. The force window does not alter the actual force pulse but minimises the noise in the rest of the data block giving a much improved signal to noise ratio.

Forced Deflection Shape

When a structure is forced to vibrate by applying one or more excitation forces, the structure will exhibit what is known as a Forced Deflection Shape.

Forced Response Analysis

Calculating the system response to an arbitrary forcing function using modal analysis data as the system model.

Forced Vibration

The oscillation of a system under the action of a forcing function.

Foundation

A surface to which a machine baseplate is mounted.

Fourier Analysis

Application of the Fourier transform to a signal to determine its spectrum. Fourier analysis is another term for spectrum analysis, although it generally refers to analysis using an FFT analyzer.

Fourier, Jean Baptiste

The famous, many-talented French engineer, mathematician, and one time president of Egypt, who devised the Fourier series and Fourier Transform for the conversion of time functions into frequency functions and vice versa.

Fourier Spectrum

The line spectrum resulting from an FFT analysis is equally spaced, so the time signal is analysed in constant bandwidths. The analyzer analyses the time signal in blocks and each block is recorded in memory and a Fast Fourier Transform (FFT) is performed on each block (the old instantaneous spectrum). See also FFT Analysis.

Fourier Transform

A mathematical operation for decomposing a time function into its frequency components (amplitude and phase). The process is reversible, and the signal can be reconstructed from its Fourier components. See also Fast Fourier Transform.

Free Field

An environment in which there are no reflective surfaces within the frequency region of interest and the sound is isotropic and homogenous.

Free-field Voltage Sensitivity

The ratio of the output open-circuit voltage of a microphone to the free-field sound pressure in an undisturbed plane progressive wave. Frequency and angle of incidence must be specified.

Free Run

When using free run triggering, the analyzer runs continuously capturing time records and calculating the corresponding spectra.

Free Sound Field

A sound field in which the effects of obstacles or boundaries on sound propagated in that field are negligible.

Frequency

Frequency is the reciprocal of time. If an event is periodic in time, that is, if it repeats itself at a fixed time interval, then its frequency is one divided by the time interval. If a vibrating element takes one tenth of a second to complete one cycle and return to its starting point, then its frequency is defined to be 10 cycles per second, or 10 hertz (Hz). Although the SI standard unit of frequency is the Hz, when analysing machinery vibration it is sometimes more convenient to express frequency in cycles per minute (cpm), which corresponds to rpm. Frequency in cpm is simply frequency in Hz times 60. Another common frequency representation used in machinery monitoring is multiples of turning speed, or “orders”. Frequency in orders is frequency in cpm divided by the turning speed of the machine. The second order is then the second harmonic of turning speed, etc. This is especially convenient if the machine is varying in speed, for the frequency representation on a spectrum will be the same regardless of speed. Two spectra from the same machine can therefore more easily be compared if they are both expressed in orders. Conversion of the frequency axis of a spectrum to orders is called “order normalisation”, and is done by vibration monitoring analyzers.

Frequency Domain

Vibration exists in time, and it is said to be in the “time domain”. The representation of a vibration signal in the time domain is a “wave form”, and this is what one would see if the signal were displayed on an oscilloscope. If the waveform is subjected to a spectrum analysis, the result is a plot of amplitude versus frequency, called a spectrum, and the spectrum is in the frequency domain. The waveform is “transformed” from the time domain to the frequency domain. Most detailed analysis of machinery vibration data is done in the frequency domain, but certain information is more easily interpreted in the time domain.

Frequency Range

This is the maximum frequency span that it is possible to measure. See also Frequency Span.

Frequency Response

The changes in the sensitivity of a circuit or device with frequency. The frequency response function, also called the FRF, is a characteristic of a system that has a measured response resulting from a known applied input. In the case of a mechanical structure, the frequency response is the spectrum of the vibration of the structure divided by the spectrum of the input force to the system. To measure the frequency response of a mechanical system, one must measure the spectra of both the input force to the system and the vibration response, and this is most easily done with a dual-channel FFT analyzer. Frequency response measurements are used extensively in modal analysis of mechanical systems.

Frequency Response Function

The output to input relationship of a structure. Mathematically, it is the Fourier transform of the output divided by the Fourier transform of the input.

Frequency Response Matrix

For an N degree of freedom system, it is an N x N symmetrical matrix whose elements are the frequency response functions between the various points on the structure. Rows correspond to response points and columns to excitation points. For example, H23 is the frequency response with excitation at point 3 and response at point 2.

Frequency Span

The frequency range of interest in a measurement. This can be the measured or displayed frequency span. The frequency span can be equal to or less than the Frequency Range that the hardware/software in use allows to be measured.

Frequency Sweep Test

A test in which a specimen is excited at a constant force or acceleration level while the frequency is swept (varied from low to high, and then back to low again).

Frequency Weighting

Modification of the frequency spectrum of a signal by means of a filter having a conventional characteristic known as A, B, C or D. A-weighting is the most commonly used.

Front-end

Data acquisition hardware.

FTC

Frequency Time Curve. A graph of time versus frequency with magnitude displayed as dB contour lines.

FTF

See Fundamental Train Frequency.

Fundamental

The basic pitch of a musical note.

Fundamental Frequency

The lowest frequency of a vibrating system. The spectrum of a periodic signal will consist of a fundamental component at the reciprocal of the period and possibly a series of harmonics of this frequency. The frequency is directly related to the phase-locked, rotational speed being measured and its amplitude may be low enough that it is difficult to see in the spectrum (or it may be missing altogether). The spectrum of a periodic signal will consist of a fundamental component at the reciprocal of its period and a series of harmonics of this frequency. The fundamental is also called the "first harmonic". Even if the fundamental is so low in level that it cannot be seen, the harmonics will still be spaced apart by the fundamental frequency.

Fundamental Train Frequency (FTF)

The rotation frequency or rate of the cage supporting the rolling elements in an anti-friction bearing. The FTF is always less than one-half shaft turn speed.

Fusion Zone

All reflections arriving at the observer's ear within 20 to 40 ms of the direct sound are integrated, or fused together, with a resulting apparent increase in level and possible pleasant change of character. This is the Haas Effect.

Gain

The increase in level of a signal produced by an amplifier.

Gated Analysis

Gated measurements are used on cyclic and repetitive signals from "slowly" rotating machines to extract information about individual events in a cycle. Results are often shown in a waterfall plot with the spectra plotted as a function of crankshaft angle against one or two machine revolutions.

Gaussian Window

The Gaussian window has the form e^{-x^2} on a logarithmic scale (dB) and generates an inverted parbola with no side lobes. This provides a smoothing weighting function, which increases the bandwidth.

Generalised Co-ordinates

The minimum number of independent co-ordinates necessary to completely describe a systems position constitutes a set of generalised co-ordinates. For an N degree of freedom system, N generalised co-ordinates are required.

Graphic Level Recorder

A device for recording signal level in dB versus Time on a tape. The level in dB versus Angle can be recorded also for directivity patterns.

Grating, Diffraction

An optical grating consists of minute, parallel lines used to break light down into its component colors. The principle is now used to achieve diffraction of acoustical waves.

Grating, Reflection Phase

An acoustical diffraction grating to produce diffusion of sound.

Haas Effect

Also called the precedence effect. If similar sounds arrive at the ear within approximately 35 ms, the apparent direction of the sound is that of the direct sound. The auditory apparatus integrates delayed sounds if they fall on the ear within 20 to 40 ms of the direct sound. The level of the delayed components contributes to the apparent level of the sound, and may be accompanied by a pleasant change in the character of the sound. See Fusion Zone.

Hair Cell

The sensory elements of the cochlea that transduce the mechanical vibrations of the basilar membrane to nerve impulses that are sent to the brain.

Hamming Window

Named after its originator, the Hamming window is a Hanning window sitting on top of a small rectangular pedestal. Its function is similar to the Hanning window, but has its first side lobes 42 dB down, whereas the Hanning window's first side lobes are only 32 dB down. Thus, the Hamming window has better selectivity for large signals, but it suffers from the disadvantage that the rest of the side lobes are higher, and in fact fall off slowly at 20 dB per octave like those of the rectangular window. The Hamming window had some advantage in the days when FFT analyzers only had 50 dB or so of dynamic range, but nowadays it is essentially obsolete.

Hand-arm Co-ordinate System

The axes of the co-ordinate system are mutually perpendicular. The origin of the co-ordinate system is in the centre of the root joint of the middle finger.

Hand-arm Vibration

This is a quantitative measure of the effect of vibration on the human arm, for example, when using power tools over a prolonged period of time. The main application areas are hand-held construction machinery (pneumatic and electrically powered tools, chain saws, etc.) and the automotive industry (motorcycles, mopeds, etc.).

Hanning Window

A smooth amplitude weighting of the time signal that is zero at the beginning and the end of the time record. Used with gated continuous signals and long transients to give them a slow onset and cut-off in order to reduce the generation of side lobes in their frequency spectrum. The selectivity of the Hanning window is good, and the maximum picket-fence-error is 1.42 dB.

Harmonic

A discrete sinusoidal (pure-tone) component whose frequency is an integer multiple of the fundamental frequency of the wave. If a component has a frequency twice that of the fundamental, it is called the second harmonic, etc.

Harmonic Response

In a situation where the (stationary) process forces in a structure are cyclical (which is typical for the free forces and moments from rotating machinery), the vibration spectrum, when measuring the response at an arbitrary position on the structure, is usually characterised by one or more predominant lines. Such a response spectrum is known as harmonic response.

Harmonic Series

Components of a spectrum that are integer multiples of the fundamental frequency. A harmonic series in a spectrum is the result of a periodic signal in the waveform. Harmonic series are very common in spectra of machinery vibration.

HATS

Head and torso simulator used for sound quality and telecom measurements.

Head-related Transfer Function (HRTF)

Due to the direction-dependent scattering caused by a torso, head and pinnae, sounds reaching the ears of a listener are essentially different. The scattering can be determined by measuring head-related transfer functions, which represent the filtering of sounds from a free field to a measurement point at the ears of the listener.

Headphones

An assembly comprising two earphones and a headband or equivalent device to hold these in place with a chosen force.

Headroom

The amount of room between the normal operating level and the maximum level where clipping (distortion) occurs. This number tells you how much louder a signal can get before distortion

Hearing Level

A measured threshold of hearing at a specified frequency expressed in decibels relative to a specified standard of normal hearing. The deviation in decibels of an individual's threshold from the zero reference of an audiometer.

Hearing Loss

A term denoting an impairment of auditory acuity. The amount of hearing impairment, in decibels, measured as a set of hearing threshold levels at specified frequencies. Types of hearing loss are: 1. Conductive: A loss originating in the conductive mechanism of the ear; 2. Sensor-neural: A loss originating in the cochlea or the fibres of the auditory nerve; 3. Noise induced: A sensor-neural loss attributed to the effects of noise. Measured in dB below a standard level. Hearing loss can be related to disease, injury, age or exposure to high-level sound.

Hearing Protector

A general term embracing earmuff, earplug, and helmet (or other noise excluding device) worn on the head.

Hearing Threshold Level (HTL)

A measured threshold of hearing, expressed in decibels relative to a specified audiometric zero. The amount by which an individual's threshold of audibility differs from a standard audiometric threshold.

Helmholtz Resonator

A reactive, tuned, sound absorber. A bottle is such a resonator. Helmholtz resonators can employ a perforated cover or slats over a cavity.

Henry

The unit of inductance.

Hertz (Hz)

The unit of frequency, abbreviated as Hz. One hertz is equal to one cycle per second. The name is in honour of Heinrich Hertz, an early German investigator of radio wave transmission. See also Frequency.

High-Pass Filter

A filter that passes signal frequencies above a specific, or cut-off, frequency but attenuates low-frequency components. They are used in instrumentation to eliminate low-frequency noise, and to separate alternating components from direct (DC) components in a signal.

Hilbert Transform

A mathematical transform that changes real-valued time functions (correlation functions, impulse response functions, etc.) into complex-values time functions whose imaginary part is the Hilbert Transform of the original real-valued time domain signal. The complex-valued time domain functions are called analytic signals and can be displayed in terms of magnitude and phase versus time. The magnitude of the analytic signal describes the envelope of the original signal and the phase leads to an "instantaneous frequency" for signals sweeping in frequency with time.

Hysteresis

Non-uniqueness in the relationship between two variables as a parameter increases or decreases. Also called dead-band, or the portion of the system's response where a change in input does not produce a change in output.

Hysteresis Damping

(Hysteretic Damping, Structural Damping). Energy losses within a structure that are caused by internal friction within the structure. These losses are independent of speed or frequency of oscillation but are proportional to the vibration amplitude squared.

Hysteresis Value

Lagging effect. Specifies a minimum percentage change in a tacho signal relative to the maximum input for the tacho channel that must occur after the slope and level conditions have been met for identification and triggering of a tacho pulse.

Ideal Filter

A rectangular filter with unity amplitude transfer within its pass band and zero transfer outside its pass band.

Imaginary

The opposite of real. A function can have imaginary roots as well as real roots.

Imaginary Intensity

Imaginary intensity is the non-propagating part of the sound field (sometimes called the reactive part).

Imaginary Part Plot

A plot of the imaginary part of the frequency response function versus frequency. For a single-degree-of-freedom system, the magnitude is a maximum or minimum at the damped natural frequency.

Immittance

A generic term embracing acoustic impedance, acoustic admittance, acoustic compliance, equivalent air volume, and related quantities determined by Immittance Audiometry.

Immittance Audiometry

Determination of the acoustical properties (impedance, admittance, etc.) of the middle ear.

Impact

Excitation of a structure with a force pulse, for example, using an Impact Hammer.

Impact Hammer

A hammer designed to excite and measure impact forces on structures.

Impact Insulation Class (IC)

A single-figure rating that compares the impact sound insulating capabilities of floor-ceiling assemblies to a reference contour.

Impact Sound

The sound produced by the collision of two solid objects. Typical sources are footsteps, dropped objects, etc., on an interior surface (wall, floor, or ceiling) of a building.

Impact Testing

A method of measuring the frequency response function of a structure by hitting it with a calibrated Impact Hammer and measuring the system's response. The instrumented impact hammer has a transducer to measure the input force pulse while the response is typically measured using an accelerometer. The impact imparts a force pulse that excites the structure over a broad frequency range.

Impedance

The opposition to the flow of electric or acoustic energy measured in ohms. The complex ratio of voltage to current.

Impedance (acoustic)

see Immittance.

Impedance Matching

Maximum power is transferred from one circuit to another when the output impedance of the one is matched to the input impedance of the other. Maximum power transfer may be less important in many electronic circuits than low noise or voltage gain.

Impedance Matrix method

A method of calculating structure-borne contributions, wherein the FRF matrix is used to estimate operating forces. Also referred to as matrix method, inertance method or indicator method.

Impedance, Mechanical

The mechanical impedance of a point on a structure is the ratio of the force applied to the point to the resulting velocity at the point. It is a measure of how much a structure resists motion when subjected to a given force, and it is the reciprocal of Mobility. The mechanical impedance of a structure varies in a complicated way as frequency is varied. At resonance frequencies, the impedance will be low, meaning very little force can be applied at those frequencies. Mechanical impedance measurements of machine foundations are sometimes made to insure their suitability for the machine in question. For instance, it would not be good to have a foundation resonance near the turning speed of the machine.

Impedance, Specific Acoustic

The complex ratio of dynamic pressure to particle velocity at a point in an acoustic medium, measured in rayls (1 rayl = 1 N s/m3).

Impulse

A single pulse. A very short, transient, electric or acoustical signal, normally used to test a systems response.

Impulse Response

The response of a system to a unit impulse or Dirac's delta function. The Fourier transform of the impulse response is the frequency response function.

Impulsive Noise

a) Either a single sound pressure peak (with either a rise time less than 200 milliseconds or total duration less than 200 milliseconds) or multiple sound pressure peaks (with either rise time less than 200 milliseconds or total duration less than 200 milliseconds) spaced at least by 200 millisecond pauses, b) A sharp sound pressure peak occurring in a short interval of time.

In-band Ripple

In-band ripple is a characteristic of a filter in the frequency domain. It is the variation in the signal amplitude within the band.

In-Phase

Two periodic waves reaching peaks and going through zero at the same instant are said to be "in phase".

Inclinometer

A gravity device that measures angular position in degrees.

Indicator point

Position of acoustic/vibration indicator measurement.

Indicator-to-path matrix

A matrix of transfer functions used in structure-borne contribution analysis. Also referred to as impedance matrix.

Inductance

An electrical characteristic of circuits, especially of coils, that introduces inertial lag because of the presence of a magnetic field. Measured in henrys.

Inertance

The frequency response function of acceleration/force. Also known as accelerance.

Infrasound

Sound at frequencies below the audible range, that is, below about 16 – 20 Hz.

Initial Time-delay Gap

The time gap between the arrival of the direct sound and the first sound reflected from the surfaces of the room.

Input

A location (point or region) where one measures sensitivity to receiver and source strength under operational conditions. In structure-borne contribution measurements, this may be called path, while in airborne contribution measurements, it may be called point source.

Insertion Loss

The sound level reduction at a given location due to the insertion of a noise control device, expressed in decibels. The difference, in decibels, between the sound pressure level before and after the effect of a sound-attenuating device.

Integrating-averaging Sound Level Meter

A development of the sound level meter. In its "averaging" mode the instrument provides a direct reading of the sample equivalent continuous sound level $L_{eq}(s)$. In its "integrating" mode, if provided, it reads Sound Exposure Level L_{EA} directly. See Sound Level Meter and Sound Exposure Level.

Integration

Integration is the mathematical operation that is the inverse of Differentiation. In vibration analysis, integration will convert an acceleration signal into a velocity signal, or a velocity signal into a displacement signal. Integration can be done with excellent accuracy with an analog integrator in the time domain or can be done digitally in the frequency domain. For this reason, an accelerometer is the transducer of choice because velocity and displacement can be so easily derived from its output. An analog integrator is actually a low-pass filter with 6 dB of attenuation per octave. This is true of an analog integrator only above its low cut-off. And since the low cut-off cannot be zero, analog integrators have low-frequency limits, usually either 1 or 10 Hz.

Integrator

An electrical frequency filter used to convert a vibratory acceleration signal to one whose amplitude is proportional to velocity or displacement.

Intensity

Intensity is the real part of the complex intensity and is the propagating part of the sound field (sometimes called the active part).

Interference

The combining of two or more signals results in an interaction called interference. This may be constructive or destructive. Another use of the term is to refer to undesired signals.

Intermodulation Distortion

Distortion produced by the interaction of two or more signals. The distortion components are not harmonically related to the original signals.

Interpolation

Calculation of new intermediate values based on a number of existing measured values.

Interval Sampling

Measuring at a number of pre-defined times. For example, 2 seconds every 2 hours.

Inverse Square Law

A description of the acoustic wave behaviour in which the mean-square pressure varies inversely with the square of the distance from the source. This behaviour occurs in free-field situations, where the sound pressure level decreases 6 dB with each doubling of distance from the source. See Spherical Divergence.

ISO

Abbreviation for International Standards Organisation, the international organisation for standardisation.

Isolation

Resistance to the transmission of sound by materials and structures.

ITD

Initial time-delay gap.

JAES

Journal of the Audio Engineering Society.

JASA

Journal of the Acoustical Society of America.

Jerk

A vector quantity that specifies time rate of change of acceleration.

Jury Test

A tool used to present a series of test sounds to a jury of listeners.

Kaiser-Bessel Time Window

A smooth weighting function similar to the Hanning window. It is zero at the beginning and end of the time record. Formula: 1 - 1.24cos(2Dt/T) + 0.244cos(4Dt/T) - 0.00305cos(6Dt/T). The Kaiser-Bessel window has the best frequency selectivity. Use it to separate closely spaced frequency components with widely different levels.

kHz

1000 Hz.

Kurtosis

The degree of peakedness of a distribution

L-weighting

Linear weighting. All values are weighted equally in the specified range.

Lateral Location

The physical location of a rotor relative to the fixed, or non- rotating parts of the machine.

Law of the First Wavefront

The first wavefront falling on the ear determines the perceived direction of the sound.

Ldn

A 24-hour L_{eq}, except 10 dB is added to all levels measured between 2200 and 0700 hrs.

Leading Edge

The part of the signal near the start of the time window.

Leakage

In an FFT analyzer, the input signal is recorded in time blocks, called time records, and individual spectra are computed from each block of data. Because the input signal period is not synchronised with the duration of the time block, the signal will be truncated at the beginning and end of the block. This truncation causes an error in the calculation, which effectively spreads out, or “smears”, the spectrum in the frequency domain. This phenomenon is called leakage; the signal energy essentially “leaks” from a single FFT line to adjacent lines. Leakage reduces the accuracy of the measured levels of peaks in the spectrum, and reduces the effective frequency resolution of the analysis. Leakage is worst for continuous signals and rectangular window, and it is greatly reduced by use of the Hanning Window, which forces the signal level to zero at the ends of the data block.

LED

Light emitting diode.

LEPN

Effective Perceived Noise Level. A complex rating used to certify aircraft types for Flyover Noise. Includes corrections for pure tones and for duration of the noise.

Leq

See Equivalent Continuous Sound Pressure Level.

Level

A sound pressure level in dB means that it is calculated relative to the standard reference level of 20 μPa for airborne sound. The word “level” associates that figure with the appropriate standard reference level. In common usage the level of a signal is its amplitude, but strictly speaking the term should be reserved for the amplitude expressed on a decibel scale relative to a reference value.

LFD

Low-frequency diffusion.

Liftering

A technique to separate harmonic vibration families. The main application for Cepstrum analysis is analysis of gearboxes. Liftering is used to separate the different harmonic vibration families from the various rotating shafts.

Line Amplifier

An amplifier designed to operate at intermediate levels. Its output is usually on the order of one volt.

Line Drive

An input socket that can also provide power to drive a transducer.

Line Source

A sound source composed of many point sources in a defined line, such as a train, flow of traffic on a motorway, or constant aircraft take-offs and landings.

Line Spacing

In an FFT spectrum, the frequency difference between two adjacent bin centres or lines.

Line Spectrum

A line spectrum is a spectrum where the energy is concentrated at specific frequencies (lines or bins), as opposed to a continuous spectrum where the energy is smeared out over a band of frequencies. A periodic deterministic signal will have a line spectrum, and a random signal will have a continuous spectrum. Spectra generated by machine vibration signatures are always a combination of these two types.

Linear

A device or circuit with a linear characteristic means that a signal passing through it is not distorted.

Linear Taper

Attenuation by a numerical factor that increases or decreases linearly with time.

Live End-Dead End

An acoustical treatment plan for rooms in which one end is highly absorbent and the other end reflective and diffusive.

LN

The dB(A) level exceeded N % of the time, for example, L_{90}, the dB(A) level exceeded 90% of the time, is commonly used to estimate ambient noise level.

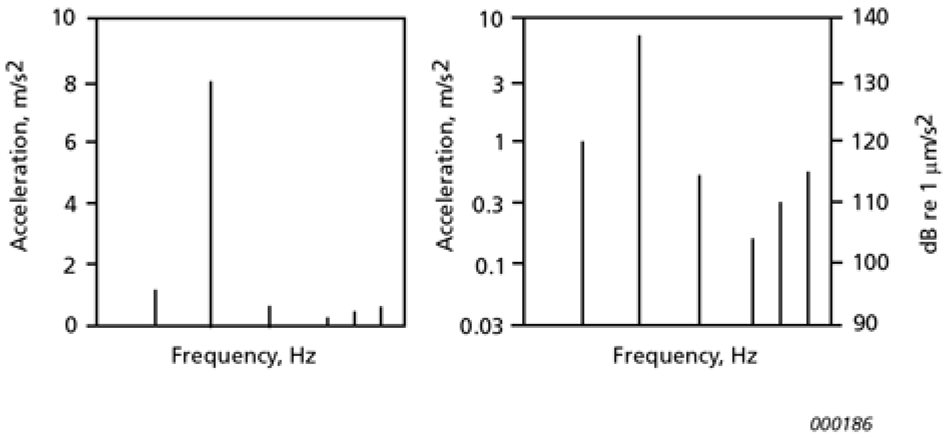
LNP

Noise Pollution Level. A variation of L_{eq} which accounts for short-term variability in noise level.

Logarithm

The exponent required (power to which a number must be raised) to produce a given number. For example, used in acoustics, 10 to the exponent 2 = 100; the log of 100 = 2.

Logarithmic Amplitude Scale



Critical vibration components usually occur at low amplitudes compared to the rotational frequency vibration. These components are not revealed on a linear amplitude scale because low amplitudes are compressed at the bottom of the scale. But a logarithmic scale shows prominent vibration components equally well at any amplitude. Moreover, percent change in amplitude may be read directly as dB change. Therefore, noise and vibration frequency analyses are usually plotted on a logarithmic amplitude scale.

Loudness

An observer's auditory impression of the strength of a Loudness: The subjective judgement of intensity of a sound by humans. Loudness depends upon the sound pressure and frequency of the stimulus. Over much of the frequency range it takes about a threefold increase in sound pressure (a tenfold increase in acoustical energy, or, 10 dB) to produce a doubling of loudness. The unit is the Sone. The Zwicker method of calculation of stationary loudness is described in ISO 532 B and DIN 45631.

Loudness Level

Measured in phons it is numerically equal to the median sound pressure level (dB) of a free progressive 1000 Hz wave presented to listeners facing the source, which in a number of trials is judged by the listeners to be equally loud. Loudness level can be calculated according to ISO 532B.

Loudspeaker

An electro-acoustical transducer that changes electrical energy to acoustical energy.

Low-pass Filter

A filter that passes signals with less than 3 dB attenuation up to its cut-off frequency, and attenuates the signal above that frequency. The attenuation slope is called the Roll Off. An Anti-aliasing Filter is an example of a low-pass filter.

LSEL

Single Event Noise Exposure Level. The dB(A) level which, if it lasted for one second, would produce the same A-weighted sound energy as the actual event.

Manual Trigger

A manual trigger is when the operator clicks on a button to initiate recording of data to disk or capture of time records for measurement.

Masked Threshold

Threshold of hearing measured in the presence of a masking sound (usually random noise of specified bandwidth).

Masking

The process and amount by which the threshold of audibility of a signal at a particular frequency is raised by the presence of another signal at a frequency close by. The frequency range over which the masking effect extends is dependent on the SPL of the masking signal. Masking also occurs in the time domain when a short transient sound masks the audibility of other sounds both before and after the transient. The process by which the threshold of hearing of one sound is raised due to the presence of another sound (the "masker").

Masking Noise

A noise that is intense enough to render inaudible or unintelligible another sound that is also present.

Mass Law

Relationship of the doubling in mass or frequency to a 6 dB increase in threshold level for a uniform partition over a defined frequency range.

Mass Matrix

In modal testing, represents the inertial properties of the model.

Material Testing

This is the testing of the dynamic properties of materials, leading to quieter, stronger, more reliable manufactured products by minimising the effects of resonances. The main application areas are: the automotive and aerospace industries, consumer products and household goods, process machinery, machine tools and packaging machinery.

Mean Free Path

For sound waves in an enclosure, it is the average distance travelled between successive reflections.

Mecatronics

The intelligent integration of mechanical engineering, micro/electronics and computer control in product and process design. The main application areas are in consumer products (CD players, auto-focus cameras, disk drives, etc.) and process machinery (robotics, computer controlled lathes, textile machines, etc.).

Mechanical Impedance

Ratio of applied force to resulting velocity during simple harmonic excitation. Called driving point impedance if force and velocity are measured at the same point, otherwise called transfer impedance.

Formulae

$$Z = \frac{F}{v} = \frac{F}{\omega d} = \frac{\omega F}{a}$$

having units of $\frac{\text{lb} \cdot \text{sec}}{\text{inch}}$ or $\frac{\text{newton} \cdot \text{sec}}{\text{meter}} = \frac{\text{Ns}}{\text{m}}$

Dynamic mass: $Z_a = \frac{F}{a}$

Dynamic stiffness: $Z_d = \frac{F}{d}$ where all terms are phasors, having a magnitude and direction.

Mass = Force/Acceleration

Medium

A substance carrying a sound wave.

Metrics

A term used to describe objective psychoacoustic measurements such as those derived from Zwicker: Loudness, sharpness, roughness, and fluctuation strength.

Microphone

An acoustical-electrical transducer by which sound waves in air may be converted to electrical signals.

Middle ear

The cavity between the eardrum and the cochlea housing the ossicles connecting the eardrum to the oval window of the cochlea.

Milliradian

This is one thousandth of a radian. A radian is an angle whose subtended arc is equal to the radius at which the arc is measured. It amounts to about 57.3 degrees. There are 2 ☐ radians in a circle. A unit (normally metric) used to describe the angle of one machine centreline to the other. It is the equivalent to 1 mils/inch. It can also be expressed as rise/run. (1 unit = 17.45 milliradians).

Millisecond

One thousandth of a second, abbreviated to ms.

Mils

A unit of measure for displacement (thousandths of an inch). Usually measured in mils peak to peak, which represents total displacement.

Mils/Inch

A unit (normally English) used to describe the angle of one shaft centreline to the other. It is equivalent to milliradians. It can also be expressed as rise/run (1 unit = 17.45 mils/inch), as long as the rise is measured in mils and the run is measured in inches.

Mixer

A device, sometimes very elaborate, that is used for combining signals from many sources.

Mobility

Mechanical admittance. The frequency response function of velocity/force. Mobility is the inverse of mechanical impedance. It is a measure of the ease with which a structure is able to move in response to an applied force, and varies it with frequency. The vibration measured at a point on a machine is the result of vibratory forces acting somewhere in the machine. The magnitude of the vibration is equal to the magnitude of the force times the mobility of the structure. From this it follows that the amplitude of the destructive forces acting on a machine are not determined directly by measuring its vibration if the mobility of the machine is not known. For this reason, it is a good idea to measure the mobility at the bearings of a machine in order to find out the levels of the forces acting on the bearings due to imbalance or misalignment. See also Impedance, Mechanical.

Modal Analysis

The process of determining a set of generalised co-ordinates for a system such that the equations of motion are both inertially and elastically uncoupled. More commonly, it is a process of determining the natural frequencies, damping factors, and mode shapes for a structure. This is usually done either experimentally through frequency response testing or mathematically using finite element analysis.

Modal Damping (or decay rate)

Describes the rate at which a structure dissipates vibrational energy.

Modal Density

Describes how closely the modal frequencies are spaced in a structure.

Modal Frequency

The natural frequency at which a structure vibrates in a free response with no external forces.

Modal Mass

The scaling constant that relates Mode Shapes (which are intrinsically unscaled) and Residues.

Modal Matrix

A collection of all Mode Shapes gathered together as columns.

Modal Parameters

A set of parameters necessary to quantify the modal properties of a structure, for example, Modal Frequency, Modal Damping, etc.

Modal Property (or Modal Behaviour)

The rather surprising observation that all structures, regardless of their geometrical continuity (properties) behave in a discrete sense, that is, they only seem to absorb energy at particular frequencies, the frequencies at which they vibrate and, in turn, dissipate energy.

Modal Resonance

see Mode.

Modal Testing

The term is synonymous with Experimental Modal Analysis. This requires a physical structure, typically a prototype or scale model. For example, using "shaker excitation", the structure is excited by a measurable force and the associated response is observed over a representative number of Degrees of Freedom (DOFs). Frequency response functions are estimated between excitation and response DOFs, and form the data set from which the modal parameters are estimated. The parameter estimation is made using the curve fitting technique, where the modal parameters of the underlying theoretical model are estimated using a least squares technique. See also Modal Analysis.

Mode

A room resonance. Axial modes in rectangular rooms are associated with pairs of parallel walls. Tangential modes involve four room surfaces and oblique modes all six surfaces. Their effect is greatest at low frequencies and for small rooms.

Mode Shape

The relative position of all points on a structure at a given natural frequency.

Model Correlation

This structural testing technique involves testing an analytical model by comparing it directly with an experimental model.

Model Reduction

In this structural analysis technique, the number of degrees of freedom is reduced in the analytical model to fit the number of degrees of freedom used for experimental models.

Model Update

Where an analytical model is adjusted (improved) by applying the data from an experimental model.

Model Verification

For experimental models, reciprocity measurements are used where synthesised non-measured frequency response functions are compared to measurements in order to verify the validity of a model.

Monaural

See Monophonic.

Monaural Sound Recording

A sound recording in which only one channel is used. If there are facilities for recording two channels (stereo or binaural sound) but only one channel is chosen, then the left channel is usually chosen as the default.

Monophonic

Single-channel sound.

Motion of a Single-Degree-of-Freedom System

natural frequency: $f_n = \frac{\omega}{2\pi} = \frac{1}{2\pi}\sqrt{\frac{k}{m}} = \frac{1}{2\pi}\sqrt{\frac{g}{\delta_{st}}}$

where:

- δ_{st} = static deflection
- ω = angular frequency in radians
- k = $\frac{force}{deflection} = \frac{m\,a}{d}$

transmissability (undamped): $T = \frac{1}{1-\omega^2/\omega_n^2} = \frac{1}{1-f^2/f_n^2}$

critical damping: $C_c = 2\sqrt{km}$

damping ratio: $\zeta = \frac{C}{C_c} = \frac{c}{2\sqrt{km}}$

amplification factor (at resonance): for $\zeta < 0.1, Q = \frac{1}{2\zeta}$

Mount

Structure that isolates/separates active source (engine, etc.) from passive structure.

Mount Stiffness Method

A method of analysing structure-borne contributions, wherein the operational forces are estimated using displacement and mount stiffness. Also referred to as displacement method, stiffness method, complex stiffness method, force vector method, or connection stiffness method.

Multi-degree-of-freedom

A system where more than one input can vary with time.

Multi-order

Where there are several predominant frequency orders present.

Multi-pass Analysis

An analysis based on using a number of passes to record the measurement data.

Multi-spectrum

A one- or two-dimensional array of spectra. A multispectrum consists of two or more spectra that were recorded during the same measurement.

Multi-track

A system of recording multiple tracks on magnetic tape or other media. The signals recorded on the various tracks are then “mixed down” to obtain the final recording.

Multi-value Graph

A type of graph that allows the overall levels for a number of different functions to be displayed side by side.

Multiple-degree-of-freedom System

An N-degree-of-freedom system is a system whose position in space can be completely described by N co-ordinates or independent variables. This is the generalised structural model.

Multiple Excitation

In structural dynamic testing, for multiple input techniques, two or more exciters act simultaneously. The setup must be such that the forces remain uncorrelated. The measurement configuration must be designed so that the mechanical coupling between the exciters is minimal.

Multisine

A periodic signal where the lines in the spectrum have the same magnitude. The phase increases with the square of the frequency. This minimises the crest factor.

NAH

An abbreviation for Near-field Acoustical Holography, which is an implementation of Acoustical Holography based on spatial Fourier transforms. See also Acoustic FRF

Narrow-band Spectra

Spectra that have been measured using a narrow frequency bandwidth.

Natural Frequency

The frequency at which a resiliently mounted mass will vibrate when set into free vibration. The frequency of oscillation of the free vibration of a system if no damping were present.

Near Field

That part of a sound field, usually within about two wavelengths of a noise source, where there is no simple relationship between sound level and distance, where the sound pressure does not obey the inverse square law and the particle velocity is not in phase with the sound pressure. See also Far Field.

Newton

The force required to accelerate a 1 kg mass at 1 m/s^2. Approximately equal to the gravitational force on a 100 g mass.

Nichols Plot

The open loop frequency response function of a Servo System displayed as the logarithmic magnitude as a function of the phase. This is used to check the stability of the servo system.

NIOSH

The National Institute for Occupational Safety and Health.

Node

A point or line on a vibrating structure that remains stationary.

Noise

Any sound that is undesired by the recipient. Any sound not occurring in the natural environment, such as sounds emanating from aircraft, highways, industrial, commercial and residential sources. Interference of an electrical or acoustical nature.

Wideband noise consists of a wide range of frequencies. White noise has equal power per unit bandwidth over a specified frequency range. Pink noise has equal power in constant percentage bandwidths (for example, octave bands) over a specified frequency range.

Random noise is a desirable signal used in acoustical measurements. Random noise is a signal whose instantaneous value varies randomly with time. In the context of assessing hearing damage, any audible sound should be regarded as noise. Pink noise is random noise whose spectrum falls at 3 dB per octave: it is useful for use with sound analyzers with constant percentage bandwidths. Also, periodic or statistically random noise.

Noise Criteria (NC)

A single-number noise rating system published in 1957 to rate steady-state continuous noise in a room from all types of equipment, including fans, mixing boxes, diffusers, etc. Standard spectrum curves by which a given measured noise may be described by a single NC number.

Noise Dose Meter (dosemeter, dosimeter)

see Sound Exposure Meter.

Noise Emission Level

The dB(A) level measured at a specified distance and direction from a noise source, in an open environment, above a specified type of surface. Generally follows the recommendation of a national or industry standard.

Noise-excluding Headset

A headphone set in which each earphone is surrounded by an earcup to provide additional attenuation of the ambient noise.

Noise Exposure Forecast (NEF)

A complex criterion for predicting future noise impact of airports. The computation considers Effective Perceived Noise Level of each type of aircraft, flight profile, number of flights, time of day, etc. Generally used in plots of equal NEF contours for zoning control around airports.

Noise Floor

A measure of the signal created from the sum of all noise sources and unwanted signals within a measurement system. Signals beneath the noise floor cannot be measured.

Noise Immission Level

The total quantity of sound impinging on the ear over a long period, expressed in decibels. It can be calculated from $L_{EX, ref. duration}$ and the number of years of exposure.

Noise Isolation Class (NIC)

A single number rating derived in a prescribed manner from the measured values of noise reduction between two areas, spaces or rooms. It provides an evaluation of the sound isolation between two enclosed spaces that are acoustically connected by one or more paths.

Noise Level

For airborne sound, unless specified to the contrary, it is the A-weighted sound level.

Noise Reduction Coefficient (NRC)

A single-number rating system used to compare the sound-absorbing characteristics of building materials. A measurement of the acoustical absorption performance of a material, calculated by averaging its sound absorption coefficients at 250, 500, 1000 and 2000 Hz, expressed to the nearest multiple of 0.05.

Noise Reduction (NR)

The numerical difference, in decibels, of the average sound pressure levels in two areas or rooms. A measurement of "noise reduction" combines the effect of the sound Transmission Loss performance of structures separating the two areas or rooms, plus the effect of acoustic absorption present in the receiving room.

Non-coherent Power

The non-coherent power is the part of the output autospectrum not linearly related to the input of the system. Non-coherent power is calculated from the output autospectrum and the coherence function.

Non-destructive Zoom

Zoom analysis where no digital decimation is required.

Non-Impulsive Noise

All noise not included in the definition of impulsive noise.

Non-linear

A device or circuit is non-linear if a signal passing through it is distorted. The ratio between an input and the resulting output is not constant.

Non-order-related

The results are not coherent with the orders found during order analysis.

Non-parametric Model

In structural dynamics, this is like a "black box" that maps the inputs into outputs. Examples of non-parametric models are frequency response functions that are input/output models between two particular degrees of freedom, or the modal model, which ideally represents an input/output model for the complete structure.

Non-stationary Continuous Signals

For example, speech. Can be analysed as deterministic, random or transient signals. No general rules can be applied.

Non-stationary Signals

Signals that change with time. It can be the frequency, amplitude or statistical properties that vary.

Non-synchronous (Asynchronous)

Frequencies in a vibration spectrum that exceed shaft turning speed (TS), but are not integer or harmonic multiples of TS. See asynchronous.

Normal Mode

A room resonance. See Mode.

Normal-mode Testing

Uses sinusoidal excitation with several shakers tuned such that the structure is forced to vibrate in Normal Mode.

Note

The speed of sound in water is about 4.4 times its speed in air. Therefore, the wavelength in water will be 4.4 times the wavelength in air at any given frequency.

Noy

A linear unit of noisiness or annoyance. Null: A low or minimum point on a graph. A minimum pressure region in a room.

Nyquist

A type of plot that displays the imaginary part versus the real part.

Nyquist Plot

A plot of the real part versus the imaginary part of the frequency response function. For a single-degree-of-freedom system, the Nyquist plot is a circle. In the Nyquist plot, a resonance shows up as a circle, but there is no indication what its frequency is. The Nyquist plot is like looking down the frequency axis at the real and imaginary parts of the function.

Objective Test

A sound test analysis that is carried out without a jury but is based on user-selected metrics.

Oblique Mode

See Mode.

Occluded Ear Simulator

A device simulating the acoustic properties of the tympanic membrane and its attached structures.

Octave

A range of frequencies whose upper frequency limit is twice that of its lower frequency limit. For example, the 1000 hertz octave band contains noise energy at all frequencies from 707 to 1414 hertz. In acoustical measurements, sound pressure level is often measured in octave bands, and the centre frequencies of these bands are defined by ISO and ANSI. The sound pressure level of sound that has been passed through an octave band pass filter is termed the octave band sound pressure level. Similarly, for one-third octave bands, there being three such bands in each octave band.

Octave Band Analyzer

An instrument that measures sound levels in octave bands.

Octave Band Level

The integrated sound pressure level of only those sine-wave components in a specified octave band.

Octave Filter

A filter whose upper-to-lower passband limits bear a ratio of 2. Is preferably centred at one of the preferred frequencies given in ISO R266 and should meet the attenuation characteristic of IEC R255 and ANSI S1.11-1966 Class II. Octave filters are used to make a real-time frequency analysis. These filters are called constant percentage bandwidth (CPB) filters. Octave filters can be divided into 1/3-octave filters, 1/12- or 1/24-octave filters, depending on the required analysis resolution.

ODS

See Operation Deflection Shapes

Offset

Distance between rotational centre lines at any given normal plane, usually measured at the coupling midpoint. Usually measured in mils in the US, and mm or microns in the rest of the world.

Omnidirectional Source

A source that emits equal amounts of energy in all directions and generates spherical waves.

Operating Forces

In structure-borne contribution measurements, the forces in action during operation. Also referred to as path input strength.

Operational Data

In structure-borne contribution measurements, refers to operational conditions, such as operational speed, road conditions, etc. The data comes from the following points:

Operational Deflection Shapes (ODS)

The deformation patterns of a structure when it is forced to vibrate at a particular frequency under a particular stationary operating condition. They can be regarded as a visualisation of a particular dynamic behaviour. The main application areas are in the automotive and aerospace industries, manufacturers of process machinery and generators in power stations.

Operational Deflection Shapes Simulation

In system analysis, the inherent structural dynamic properties of a structure are determined based on Frequency Response Function measurements. When measuring the frequency response function between a number of predefined Degrees of Freedom on the structure under test, a modal model can be constructed when applying modal analysis. This modal model can then be loaded with a forcing function whereby the operational deflection shape at a chosen frequency can be determined.

Order

An expression of frequency that relates a frequency (sub-synchronous, synchronous or non-synchronous) to shaft turning speed (TS). It is calculated using the simple formula: Order = f/TS. In order analysis, the frequency axis of the spectrum is expressed in orders of shaft TS (that is, peaks may be referred to as 1 ☐ TS, 2 ☐ TS or 0.43 ☐ TS, 6.77 ☐ TS, etc.).

Order Analysis

A form of frequency analysis, used with rotating machines where the amplitude of signal frequency components is plotted as a function of multiples of the rotating frequency, that is in orders of rpm rather than in Hz or rpm. This implies that tracking is used.

Order Domain

Harmonic and sub-harmonic decomposition of a signal based on a tachometer.

Order Related

When a recurring frequency component can be identified as being related to a characteristic of the object under test.

Order Tracking

Order tracking is a special case of FFT analysis applied to variable-speed rotating machines where the sampling frequency of the analyzer is varied to be an exact multiple of the running speed of the machine while a series of spectra are recorded. The spectra are usually shown on top of one another on the page, and this is sometimes called a waterfall plot. In this way, the running speed and its harmonics will always occur at the same frequencies, or orders, in the spectrum regardless of the machine speed. Other vibration components not related to running speed, such as line frequency effects will not be synchronous with running speed, and will show up as curves on the waterfall plot. A tachometer pulse from the machine is needed to determine the FFT analyzer's sampling frequency. Some analyzers have the order tracking function built in, but others need an external frequency multiplier to derive the sampling frequency from the tachometer signal.

Oscillation

The variation with time, alternately increasing and decreasing, of (a) some feature of an audible sound, such as the sound pressure; or (b) some feature of a vibrating solid object, such as the displacement of its surface.

Oscilloscope

A cathode-ray type of indicating instrument.

OSHA

The Occupational Safety and Health Administration.

Ossicles

A linkage of three tiny bones providing the mechanical coupling between the eardrum and the oval window of the cochlea consisting of the hammer, anvil, and stirrup.

Out-of-band Noise

Noise occurring outside the bandwidth that is being measured.

Out-of-phase

The offset in time of two related signals.

Output Amplifier

A power amplifier designed to drive a loudspeaker or other load.

Oval Window

A tiny membranous window on the cochlea to which the footplate of the stirrup ossicle is attached. The sound from the eardrum is transmitted to the fluid of the inner ear through the oval window.

Overall RMS Level

A measure of the total RMS magnitude within a specified frequency range.

Overlap Processing

In the FFT analyzer, the time signal is stored in a buffer before being processed to form the spectrum. The FFT algorithm only processes the data when the time buffer is full, and after the widowing function, that is, Hanning, is applied to it. This windowing causes data at the beginning and end of the time records to be represented at the wrong amplitude values, creating errors in the spectral amplitude levels. If two time buffers are used, and if the FFT algorithm is allowed to process the signal alternately from each buffer at a rate faster than the time it takes to fill the buffers, overlap processing is said to be the result. Overlap processing is desirable when using a Hanning Window because it ensures against loss of data for parts of the signal that occur near the beginning and end of the window. Most FFT-type data collectors use 50% overlap processing as a default. An overlap of 66.7% will completely correct for amplitude errors caused by the Hanning Window.

Overlay

A type of graph that is equivalent to viewing a waterfall graph straight on so that you only see the X- and Y-axis, but you can flick through each of the spectra along the Z-axis.

Overtone

A component of a complex tone having a frequency higher than the fundamental.

p-I index

The p-I index is equivalent to the mean pressure level minus the sound intensity level.

Paired Comparison Test

A test method in which recorded sounds are compared in pairs.

Parameter

An attribute with a value (for example, weighting).

Parameter Estimation

The process of evaluating and curve fitting frequency response functions in order to estimate modal parameters.

Parametric Model

A model with structure, that is, one that includes geometry and material properties.

Partial

One of a group of frequencies, not necessarily harmonically related to the fundamental, which appear in a complex tone. Bells, xylophone blocks, and many other percussion instruments produce harmonically unrelated partials.

Partial Fields

In STSF applications one of the basic assumptions is that the total sound field consists of a small number of independent, or partial sound fields.

Partial source

An input in airborne contribution analysis (for example, top engine face).

Participation Factor

The part of the Mode Shape that coincides with the excitation Degrees-of-Freedom.

Particle Velocity (Acoustics)

The instantaneous value of the distance travelled by a particle per unit time in a medium that is displaced from its equilibrium state by the passage of a sound wave.

Pascal (Pa)

The unit in which pressure is measured. 1 Pa = 1 N/m^2.

Passband

The range of frequencies between filter cut-off frequencies defining the frequency band that is not attenuated.

Passive Absorber

A sound absorber that dissipates sound energy as heat.

Passive side

In structure-borne contribution analysis, the side which receives or transfers energy, and is thus passive. Also referred to as body side. Note: There may be sub-frames in a measurement setup, which could be considered both part of the vehicle's body and engine – it is up to the user to determine what to classify these in his SPR model

Path

An input in structure-borne contribution analysis.

Path-to-receiver FRF

A noise FRF for structure-borne contributions, and an acoustic FRF for airborne contributions. Other names and variants include: Body sensitivities, Path sensitivities, Path-to-receiver transfer function, FRF, P/F, Path sensitivities, Vibroacoustic sensitivity.

Peak

The maximum positive or negative dynamic excursion from zero (for an AC coupled signal) or from the offset level (for a DC coupled) of any time waveform. Sometimes referred to as "true peak" or "waveform peak".

Peak Pick

A parameter estimation technique where the peak value of the imaginary part of the frequency response function is used to estimate the mode shape value at that point. The phase is given by its sense (positive or negative). This method is also known as quad picking since the value is being picked off the imaginary or quadrature part of the frequency response function.

Peak Sound Pressure

The maximum absolute value of the instantaneous sound pressure in a specific time interval. Note that in the case of a periodic wave, if the time interval considered is a complete period, the peak sound pressure becomes identical with the maximum sound pressure.

Peak-to-peak

The amplitude difference between the most positive and most negative value in a time waveform, that is, the total amplitude.

Period

A signal that repeats the same pattern over time is called periodic, and the period is defined as the length of time encompassed by one cycle, or repetition. The period of a periodic waveform is the inverse of its fundamental frequency.

Periodic Random Noise

Sequences of different pseudo-random signals of the same power. The first periods of each sequence give the system time to respond to the change. The last period is used for the analysis.

Periodic Signal

A signal is periodic if it repeats the same pattern over time. The spectrum of a periodic signal always contains a series of harmonics.

Periodic Vibration

An oscillatory motion whose amplitude pattern repeats after fixed increments of time.

Permanent Threshold Shift (PTS)

The component of threshold shift that shows no progressive recovery with the passage of time when the apparent cause has been removed. Noise-induced permanent threshold shift (NIPTS) is the component of PTS associated with a noise exposure. Age-related threshold shift (ARTS) is the component of PTS related to age. It is usually assumed that these components are additive, at least for small values of the components. A permanent decrease of the acuity of the ear at a specified frequency as compared to a previously established reference level. The amount of permanent threshold shift is customarily expressed in decibels.

PFC

Phase-frequency curve.

Phase

Time lag or lead. The difference in time between two events such as the zero crossing of two waveforms, or the time between a reference and the peak of a waveform. The phase is expressed in degrees as the time between two events divided by the period (also a time), times 360 degrees. The phase of the cross spectrum reflects the time relation between the two signals.

Phase Demodulation

Angular (or torsional) vibration from rotating shafts can be measured using phase demodulation of the signal from shaft encoders mounted on the end of the shaft.

Phase Mismatch

The relative phase mismatch between the two channels in an Intensity Measuring System.

Phase Shift

The angular difference between two signals, which reflects the time difference.

Phon

Unit of measurement for Loudness Level of a sound. It Is numerically equal to the sound pressure level of a 1 kHz free progressive wave which is judged by reliable listeners to be as loud as the unknown sound.

Picket Fence Effect

The FFT spectrum is a discrete spectrum, containing information only at the specific frequencies that are decided upon by setting the FFT analyzer analysis parameters. The true spectrum of the signal being analysed may have peaks at frequencies between the lines of the FFT spectrum, and the peaks in the FFT spectrum will not be at exactly the correct frequencies. This is called Resolution Bias Error, or the Picket Fence Effect. The name arises because looking at an FFT spectrum is something like looking at a mountain range through a picket fence. By a process of interpolation, it is possible to increase the apparent resolution and amplitude accuracy of the FFT spectrum by a factor of ten. Note: The Flat Top Window provides the best weighting function for reducing picket fence error.

Piezoelectric Accelerometers

Piezoelectric (PE) accelerometers use a spring-mass system to generate a force proportional to the amplitude and frequency of vibration. The force is applied to a PE element, which produces a charge on its terminals that is proportional to the mechanical motion. An advantage of PE materials is that they are self-generating and do not require an external power source. They are also capable of operating at very high and very low temperatures, and are known for their ruggedness. A variety of designs are available.

Piezoresistive Accelerometers

PR accelerometers offer the advantage of dc response. This suits them to measurements of long duration pulses found in transportation vibration, automotive crash studies and blast testing. Because they utilise an external source of electrical energy, they have inherently low output impedance. For many applications, sensitivity is high enough that preamplification of the output is unnecessary. Standard and miniature sizes are available. System calibration checks can be performed using the turnover technique, or by shunt calibration.

Piezoresistivity

Piezoresistive (PR) strain gauge elements are solid state silicon resistors that change electrical resistance in proportion to applied mechanical stress. In the traditional design, discrete strain gauges are mechanically attached to cantilever beams and electrically connected in a Wheatstone bridge to produce an electrical signal proportional to vibratory motion. Compared to wire gauges, PR gauges are virtually free of mechanical hysteresis and have several orders of magnitude greater sensitivity. Monolithic sensors are microfabricated mechanisms that include diffused silicon strain gauges as well as the mechanical components of an accelerometer in a common silicon chip. This eliminates the epoxy joints and reduces the problem of matching gauge elements. Monolithic micromachined silicon microsensors offer outstanding reliability, high sensitivity and excellent linearity. Because of silicon's excellent yield strength and relatively high piezoresistive coefficient, sensor design stress levels can be kept low for outstanding ruggedness, while still maintaining an excellent signal-to-noise ratio.

Pink Noise

Broadband noise whose energy content is inversely proportional to frequency (-3 dB per octave or -10 dB per decade).

Pinna

The cartilaginous structure of the external ear.

Pitch

The attribute of auditory sensation that orders sounds on a scale extending from low to high. Pitch depends primarily upon the frequency of the sound stimulus, but it also depends upon the sound pressure and waveform of the stimulus.

Place Effect

The theory that pitch perception is related to the pattern of excitation on the basilar membrane of the cochlea.

Plane Wave

A wave whose wave fronts are parallel planes perpendicular to the direction in which the wave is travelling.

Plenum

An absorbent-lined cavity through which conditioned air is routed to reduce noise.

Point Source

A source whose dimensions are small compared to the propagation distances described in reference to it.

Polar Pattern

A graph of the directional characteristics of a microphone or loudspeaker.

Polarization Voltage

The polarization voltage used to drive a condenser microphone.

Post-averaging

The averaging of a signal after a measurement has been made on it.

Post-processing

The application of a mathematical function to a signal after measurement to further improve the information that can be obtained from the analysis.

Power over Ethernet

Power over Ethernet (PoE) described in the IEEE 802.3af standard, is a technology that integrates power into a standard LAN infrastructure. It provides the network device, in this case the module, with up to 15 W of power using the same cable as that used for network connection.

Power (PWR)

A scaling unit. The power of a signal is the mean value of a signal squared.

Power Spectral Density (PSD)

A scaling unit. Power spectral density is a method of scaling the amplitude axis of spectra of random rather than deterministic signals. Because a random signal has energy spread out over a frequency band rather than having energy concentrated at specific frequencies, it is not meaningful to speak of its RMS value at any specific frequency. It only makes sense to consider its amplitude within a fixed frequency band, usually 1 Hz. PSD is defined in terms of amplitude squared per Hz, and is thus proportional to the power delivered by the signal in a one-Hz band.

Power Spectrum

The average squared magnitude of multiple frequency spectra.

Power Spectrum Level

The level of the power in a band one hertz wide referred to a given reference power.

PRD

Primitive root diffuser.

Preamplifier

An amplifier used to boost the physical input signal detected at the transducer before it is sent to an input module and down the measurement chain for measurement and analysis.

Precedence Effect

See Haas Effect.

Precision Time Protocol

The IEEE 1588 Precision Time Protocol provides a protocol for synchronising the clocks of modules in a distributed measurement system, thus providing correlated data acquisition across the measurement transducers.

Under the protocol, the “best” clock in the system becomes the master clock, and all the rest become “slave” clocks. The master clock sends a “sync” packet that contains the time of packet’s departure. When this packet is received by a slave clock, it notes the arrival time according to its own clock. The difference between the two is equal to the network propagation time plus the offset between the master and slave clocks. The slave adjusts its clock, thereby reducing the difference between the two clocks to the network propagation time.

IEEE 1588 assumes that network propagation time is the same from slave to master as from master to slave. Using this assumption, the slave sends a time-stamped “delay request” to the master. The master promptly returns a “delay response” stamped with the time at which it received the request. The difference between these two time stamps is the network propagation delay and the slaves can thus adjust their clocks to match the master clock.

Predicting Sound Pressure level from Sound Power Level

- In free field: $L_p = L_w + \log Q - 20 \log r - 10.8$ dB
- Over hard reflecting plane: $L_p = L_w + \log Q - 20 \log r - 7.8$ dB
- In Reverberant Room: $L_p = L_w - 10 \log R + 6.2$ dB

where:

- r is distance in metres
- Q is Directivity Factor of the sound source
- R is the room constant in square metres

Preferred Frequencies

A set of standardised octave and third-octave centre frequencies defined by ISO R266, DIN 45401 and ANSI S1.6-1967. Octave and 1/3-octave filters are centred at preferred frequencies defined in ISO R 266. Although nominal frequencies are used to identify the filters, the true centre frequencies of 1/3-octave filters are calculated from $10^{n/10}$ where n is the band number.

Band Number	Exact Frequency (Hz)	Band Number	Exact Frequency (Hz)
0	1	6	3.9811
1	1.2589	7	5.0119
2	1.5849	8	6.3096
3	1.9953	9	7.9433
4	2.5119	10	10
5	3.1623	11	12.589

Because of the way their centre frequencies are generated, 1/3-octave filters are often referred to as 1/10-decade filters. Crossover frequencies are calculated from $10^{n/10 \pm 0,5}$. Octave filters are successive sets of three third-octave filters, starting with Bands 2 — 4.

Presbycusis

Hearing loss mainly for high tones that is attributed to the ageing process.

Pressure Conversion Chart

From To	PSI	pascal	bar	millibar	in. Hg	IN. H2O	mm Hg	mm H2O	atm	*kg/cm2
PSI	1	0.00014504	14.504	0.014504	0.49118	0.036127	0.019337	0.0014223	14.696	14.223
pascal	6894.6	1	1.00000	100	3386.5	249.08	133.32	9.8068	101320	98067
bar	0.068946	0.00001	1	0.001	0.033865	0.0024908	0.0013332	9.8068E-05	1.0132	0.98068
millibar	68.946	0.01	1000	1	33.865	2.4908	1.3332	0.98068	1031.2	980.68
in. Hg	2.0359	0.00029529	29.529	0.029529	1	0.073552	0.039368	0.0028959	29.92	28.959
IN. H2O	27.68	0.0040147	401.47	0.40147	13.596	1	0.53525	0.039372	406.78	393.72
mm Hg	51.714	0.0075006	750.06	0.75006	25.401	1.8683	1	0.073558	760	735.59
mm H2O	703.05	0.10197	10197	10.197	345.32	25.399	13.595	1	10332	1.0000
atm	0.068045	9.8692E-06	0.98692	0.00098692	0.033422	0.0024583	0.00131558	9.6788E-05	1	0.9678
kg/cm2	0.070305	1.0197E-05	1.0197	0.0010197	0.034531	0.0025399	0.0013595	0.0001	1.0332	1

Pressure Gradient

The change in pressure with distance, from lower to higher pressure, or vice versa. Used in the determination of sound intensity, the pressure gradient enables particle velocity to be measured.

Pressure-Intensity Index, LK

The reactivity index in a given direction at a point is defined as the difference between the sound intensity level and the sound pressure level measured in the given direction at that point. In practice L_K is normally negative.

Pressure-Residual Intensity Index, LK,0

The residual intensity index for a given measurement system is defined as the difference between the indicated intensity level and the measured sound pressure level when exactly the same signal is fed into the two channels of an intensity analysing system. This index will normally be negative.

Pressure Zone

As sound waves strike a solid surface, the particle velocity is zero at the surface and the pressure is high, thus creating a high-pressure layer near the surface.

Probability Density

In analysing signals, the probability density is the probability that the signal level at some point in time lies within a defined area.

Prominence Ratio

The difference between the total power in a critical band and the average power in the adjacent critical bands. If the difference is greater than 7 dB, the component is "prominent".

Proportional Damping

See Damping.

PSD

See Power Spectral Density.

Pseudo-random Noise

A periodic signal where one period is a segment of a random signal. The period is determined by the generator span and the number of generator lines.

Psychoacoustic Test Bench

Brüel & Kjær's sound quality tool used to carry out subjective and objective sound tests, and statistical regression analysis.

Psychoacoustics

The study of the interaction of the human auditory system and acoustics.

Pulse

A single or a series of pulses. The pulse shape, the width and the interval between pulses are selectable.

Pure Tone

A sound having a single frequency whose sound pressure varies sinusoidally with time. A tone with no harmonics. All energy is concentrated at a single frequency. The sound pressure is a simple sinusoidal function of the time, and characterised by its singleness of pitch.

PWR (power)

See Power.

Q factor

Sharpness of Resonance. Q-factor is the amplification ratio of resonant peaks. Note that there is an inverse relationship between Q-factor and percentage bandwidth. A measure of the losses in a resonance system. The sharper the tuning curve, the higher the Q. Another term for amplification factor.

Quadrature Picking

A manual technique that is used to estimate the mode shapes of a structure with lightly coupled modes. The technique takes the imaginary parts of the frequency response function at the modal frequency as a measure for the mode shape component for the particular mode and the particular degree-of-freedom.

Quadrature Response

Another name for the imaginary part of the frequency response function.

Quasi-periodic Signal

A quasi-periodic signal is a deterministic signal whose spectrum is not a harmonic series, but nevertheless exists at discrete frequencies. The vibration signal of a machine that has non-synchronous components resembles a quasi-periodic signal. In most cases, a quasi-periodic signal is actually a signal containing two or more different periodic components.

Quasi-stationary Signals

Signals that are divided into short time segments.

Radial Position

The average location, relative to the radial bearing centreline, of a shaft's dynamic motion. Applies only to sleeve bearings.

Random Excitation

$$G = \sqrt{B\,G_o}$$

where:

- G = rms level in g units
- B = frequency bandwidth in Hz
- G_o = acceleration density in g^2/Hz

Crest factor = $\dfrac{\text{peak magnitude}}{\text{rms magnitude}}$

Random Noise

Noise whose instantaneous amplitude is not specified at any instant of time. Instantaneous amplitude can only be defined statistically by an amplitude distribution function.

Random Noise Burst

A signal where the amplitude varies at random and the signal is not continuous, but occurs periodically.

Random Vibration

A vibration whose instantaneous amplitude is not specified at any instant of time. Instantaneous amplitude can only be defined statistically by a probability distribution function that gives the fraction of the total time that the amplitude lies within specified amplitude intervals. Pseudo, Periodic and Burst random are special forms.

Ray

At higher audio frequencies, sound may be considered to travel in straight lines, or rays, in a direction normal to the wave front.

RC Circuit

An RC circuit is used for exponential averaging, as the impulse response is a decaying exponential.

Reactance

The opposition to the flow of electricity posed by capacitors and inductors.

Reactive Absorber

A sound absorber, such as the Helmholtz Resonator, which involves the effects of mass and compliance as well as resistance.

Reactive Intensity

The part of the sound field that does not contribute to the net flow of energy.

Reactive Silencer

A silencer in air-conditioning systems that uses reflection effects for its action.

Reactive Sound Field

A sound field in which the particle velocity is 90° out of phase with the pressure. An ideal standing wave is an example of this type of field, where there is no net flow of energy, and constitutes the imaginary part of a complex sound field.

Real Modes

(Sometimes called normal modes). In a real mode, all points on the structure reach a maximum or a minimum value at the same time and all pass through equilibrium at the same time.

Real Part

A plot of the real part of the frequency response function versus frequency. For a single degree of freedom, the magnitude is zero at the damped natural frequency.

Real-time Signal

A signal that is analysed on-line in real-time (as opposed to post-analysis of a recorded signal). For true real-time analysis, overlap analysis should be possible.

Reasonably Steady Sound

A sound whose level fluctuates through a total range of less than 8 dB(A) as measured with a sound level meter set to “S” time weighting.

Receiver point

A position (and in some cases, direction) where the response of interest is measured. Example: “Driver’s right ear”.

Record Length

The length of time, T, for which each sample of a signal is recorded. With random signals, it is the recorded length that determines the accuracy of the result.

Recruitment (of loudness)

A manifestation of auditory dysfunction usually associated with the sensory elements of the cochlea. It is characterised by a raised threshold and by a more rapid rate of increase of loudness with sensation level than a normal ear.

Rectangular Time Window

A time window that has a zero value outside the specified time record and unity within the record length. In the FFT analyzer, the rectangular window is actually no window at all. It is also called rectangular weighting, or uniform weighting, and is used when the signal to be analysed is a transient rather than a continuous signal. See also Hanning Window.

Reference Sine

A pure sine wave with known characteristics. This provides a base for making comparisons.

Reference Transducer

One of the array of transducers necessary to identify the partial fields during STSF measurements. A reference transducer can be a microphone, an accelerometer, a pressure transducer inserted in the cylinder of an engine, etc.

Reference Zero (for pure tone audiometers)

For air conduction, an array of sound pressure levels of pure tones at audiometric frequencies, which correspond to the normal threshold of hearing of young persons. For each frequency the value is expressed by the sound pressure level measured in an acoustic coupler or artificial ear when the earphone, driven by a specific electrical signal, is placed on the coupler. This value is known as the Reference Equivalent Threshold Sound Pressure Level (RETSPL) for the frequency in question. The specific electrical signal is such that the sound pressure level it generates under the earphone when placed on the average human ear corresponds to the modal value of the threshold of hearing for a group of otologically normal young persons. For bone conduction, the reference zero is defined analogously by reference equivalent threshold vibration levels when the bone vibrator is loaded by a specified artificial mastoid or mechanical coupler.

Reflection (of sound)

The return of a sound wave from a surface. For surfaces large compared to the wavelength of impinging sound, sound is reflected much as light is reflected, with the angle of incidence equalling the angle of reflection.

Reflection-phase grating

A diffuser of sound energy using the principle of the diffraction grating.

Refraction

The bending of a sound wave from its original path, either because it is passing from one medium to another with different velocities or by changes in the physical properties of the medium, for example, a temperature or wind gradient in the air.

Regression (statistical) Analysis

For example, used for the correlation and comparison between objective and subjective sound quality tests.

Reliability Testing

An essential part of manufacturers' quality assurance testing. Vibration tests are used to simulate the dynamic working environment of a structure to test the structure's response before it is put into operation. The main application areas are: the automotive, aerospace and electronics industries, computers and consumer goods.

Repeatability

The consistency (or variation) of readings and results between consecutive sets of measurements. It has nothing to do with accuracy.

Repeated Root

When more than one mode shape is found at a particular modal frequency.

Residual Intensity, LI,R

The sound intensity level measured when the same signal is fed to both channels of a sound intensity measuring system.

Residual Noise

This is Ambient Noise without Specific Noise. It is the noise remaining at a point under certain conditions when the noise from the specific noise is suppressed.

Residual p-I Index

The residual pressure-intensity Index describes the phase mismatch between the two channels used for sound intensity measurements. It is equal to the mean pressure minus the intensity with the probe in a sound field where the pressure is uniform over the volume containing the microphones (for example, using Sound Intensity Calibrator Type 3541).

Residual Terms

Terms added to a curve fit algorithm to take into account the effects of modes outside the range being fitted. These terms consist of a mass term on the low-frequency end and a stiffness term on the high.

Residues

A mathematical term used to express the strength of a particular mode for a particular pair of degrees-of-freedom in the model for measured frequency response functions.

Resistance

That quality of electrical or acoustical circuits that results in dissipation of energy through heat.

Resolution

The smallest change or amount a measurement system can detect.

Resonance

Conditions of peak vibratory response where a small change in excitation frequency causes a decrease in system response.

Resonant Frequency

The frequency of maximum amplification for a given damping ratio. See Resonance.

Resonant Frequency of First Bending Mode (unloaded beams)

$$f_n = C\sqrt{\frac{EIg}{L^4 W}}$$

where:

- C = constant, function of method of support
- E = elastic modulus
- I = moment of inertia of cross section
- g = acceleration of gravity

- *L* = length
- *W* = weight per unit length

Support Method	*C*
Cantilever	0.56
Point support each end	1.57
Both ends fixed	3.56
Totally unsupported	3.56

Resonator

A device that resonates or vibrates in sympathy with a source of sound or vibration.

Resonator Silencer

An air-conditioning silencer employing tuned stubs and their resonating effect for its action.

Response

Motion or other output resulting from an excitation, under specified conditions. See Frequency Response.

Response Spectrum

The frequency response function, also called the response spectrum, is a characteristic of a system that has a measured response resulting from a known applied input. In the case of a mechanical structure, the frequency response is the spectrum of the vibration of the structure divided by the spectrum of the input force to the system. To measure the frequency response of a mechanical system, one must measure the spectra of both the input force to the system and the vibration response, which is most easily done with a dual-channel FFT analyzer. Frequency response measurements are used extensively in modal analysis of mechanical systems. The frequency response function is actually a three-dimensional quantity, consisting of amplitude vs. phase vs. frequency. Therefore, a true plot of it requires three dimensions, and this is difficult to represent on paper. One way to do this is the so-called Bode plot, which consists of two curves, one of amplitude vs. frequency and one of phase vs. frequency. Another way to look at the frequency response function is to resolve the phase portion into two orthogonal components, one in-phase part (called the real part), and one part 90 degrees out of phase (called the “quadrature” or “imaginary” part). Sometimes these two phase parts are plotted against each other, and the result is the so-called Nyquist plot.

Reverberant Field

The region in a room where the reflected sound dominates, as opposed to the region close to the noise source where the direct sound dominates. The same as diffuse field.

Reverberation

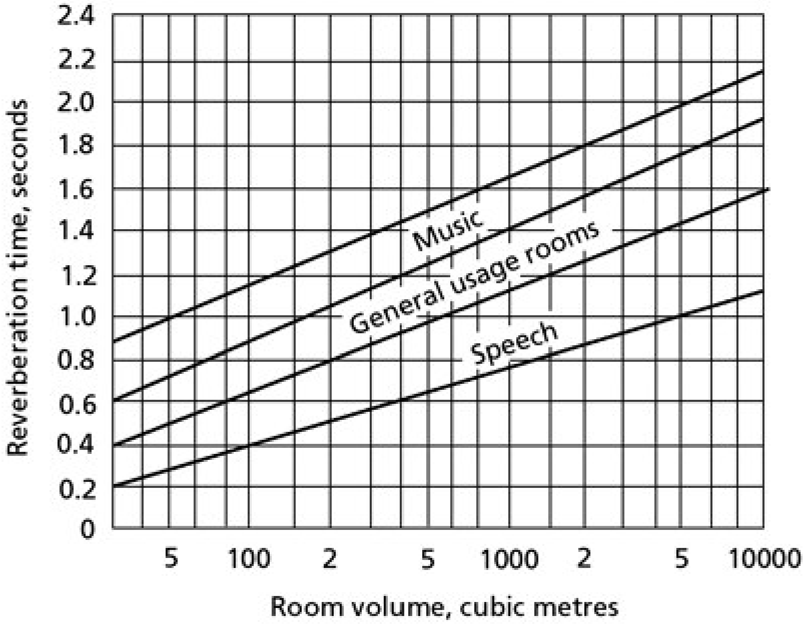
The persistence of sound in an enclosure after a sound source has been stopped.

Reverberation Chamber/Room

A room with hard boundaries and long reverberation time, especially designed to make the sound field inside it as diffuse (homogeneous) as possible. Can be used for measuring sound absorption coefficients.

Reverberation Time (RT60 or T60)

The tailing off of sound in an enclosure because of multiple reflections from the boundaries. The reverberation time of a room is the time (in seconds) taken for the sound pressure level at a specific frequency to decrease 60 dB from its steady-state value when the source of sound energy is suddenly interrupted. It is a measure of the persistence of an impulsive sound in a room as well as of the amount of acoustical absorption present inside the room. Rooms with long reverberation times are called live rooms.



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Acceptable Reverberation Times at 500 Hz

Reverse Indicator Method

Method for taking shaft alignment readings with indicators mounted radially at opposite ends of a spanned section (on each machine).

RFZ

Reflection-free zone.

Rigid Body Mode

Represents the non-deformed mode shapes of a body suspended on soft supports. Examples are a car body, ship or aircraft. A body has six rigid modes: heave, surge, yaw, pitch, roll and sway.

Ringing

High-Q electrical circuits and acoustical devices have a tendency to oscillate (or ring) when excited by a suddenly applied signal.

Ripple

Ripple appears in the pass-band of a filter. We measure the height of the ripple within ± ½ line spacing around the centre frequency in dBs. Ripple is also referred to when discussing time window weighting, as a time window is effectively a type of filter.

RMS

The root-mean-square value of a time-varying quantity is obtained by squaring the function at each instant, obtaining the average of the squared values over the interval of interest, and then taking the square root of this average. For a sine wave, if you multiply the RMS value by the square root of 2 (1.414), you get the peak value of the wave. The RMS value, also called the effective value of the sound pressure, is the best measure of ordinary continuous sound, but the peak value is necessary for assessment of impulsive noises. Also, used to describe the mathematical process of determining the average value of a complex signal.

RMS Sound Pressure

The square root of the time averaged square of the sound pressure.

Roll Off

The attenuation of a high-pass or low-pass filter is called roll off. The term is mostly used for high frequency attenuation.

Room Constant

$$R = \frac{S_t \times \overline{\alpha}}{1 - \overline{\alpha}}$$

where:

- R is the room constant in square metres
- S_t is the total area of the room in square metres
- a is the average absorption coefficient

$$\overline{\alpha} = \frac{\alpha_1 S_1 + \alpha_2 S_2 + \ldots + \alpha_n S_n}{S_1 + S_2 + \ldots + S_n}$$

where:

- a_n is the absorption coefficient of component surface, S_n

or

$$R = \frac{S_t}{\frac{T \times S_t}{0.161V} - 1} = \frac{0.161V}{T}$$

where:

- T is the reverberation time in seconds
- V is the room volume in cubic metres
- S_t is the total surface area in square metres

Room Criteria (RC)

A single-number noise rating system developed in 1981 to diagnose and rate the HVAC noise exposure in a room. This system is more effective than the noise criteria (NC) System in rating noise with strong low-frequency content.

Room Mode

The normal modes of vibration of an enclosed space. See Mode.

Root Mean Square

See RMS.

Root Mean Square Spectral Density (RMSSD)

This is the square root of the power spectral density. Root Mean Square Spectral Density (RMSSD) is a scaling unit.

Roots

The roots of the characteristic equation are complex and have a real and imaginary part. The real part describes the damping (decay rate) of the system and the imaginary part describes the oscillations or damped natural frequency of the system.

Rotational Play

Looseness, usually in a coupling, where a rotor can rotate a given distance before the rotational play is out and the coupled shaft begins to rotate also.

Roughness

A measure of the modulation amplitude and frequency modulation of a sound where the modulation is in the range from 15 to 300 Hz. Maximum roughness occurs around 70 Hz and gives the unpleasant sensation of a stationary but rough sound. Above this frequency, the time constant of human hearing starts to take effect and reduces the perception of modulation. When determining roughness, the loudness data must be sampled in real-time with a high sampling rate.

Round Window

The tiny membrane of the cochlea that opens in the middle ear that serves as a “pressure release” for the cochlear fluid.

RT60

See Reverberation Time.

Run Down

Where a motor or other rotating or reciprocating machine is decelerated downwards past an upper known RPM to a lower known RPM and a measurement is made. The tacho frequency is supposed to decrease.

Run Up

Where a motor or other rotating or reciprocating machine is accelerated upwards past a lower known RPM to an upper known RPM and a measurement is made. The tacho frequency is supposed to increase.

Sabin

A measure of the sound absorption of a surface; it is the equivalent of one square foot of a perfectly absorptive surface. One square foot of open window has an absorption of 1 sabin. Note: One metric sabin is equivalent to 1 sq. metre of perfectly absorptive surface.

Sabine

The originator of Sabine reverberation equation.

Sag

Deflection due to gravity acting on a cantilevered or otherwise supported object. Mechanical brackets that hold alignment tools always sag a certain amount. This sag must be corrected if the machine movements are to be calculated correctly.

Samples

Sets of measured data, that is, one or more measured records.

Sampling Frequency

How often data is measured. Given in hertz.

Sampling Interval

The period of time that data is measured for at each sample point.

Sampling Theorem

A theorem stating that a signal is completely described if it is sampled at a rate twice its highest frequency component.

Scaling

Peak Scaling, Peak-to-Peak Scaling, and RMS Scaling are ways of displaying the amplitude axis of a spectrum.

Scan Analysis

A non-stationary signal, or part of it, is recorded in a time buffer and afterwards analysed by stepping a Hanning window along the record.

Schmitt Trigger

A device used for filtering unstable tacho pulses to give precise on-off control.

Scientific Format

The scientific format (Sci.) is used to set up the spectrum values with an exponent, for example, 10 E3.

Selectivity

Indicates how well a filter separates components of very different levels. The ratio of a filter's −3 dB Bandwidth to its −60 dB Shape Factor. Selectivity is also referred to when discussing time window weighting, as a time window is effectively a type of filter. Selectivity is a measure of the narrowness of a band-pass filter. The greater the selectivity, the narrower, or more selective, the filter.

Self-test

A built-in routine to check that all the required functions are operating properly.

Semantic Differential Test

A test method in which recorded sounds are listened to and judged one at a time.

Semi-anechoic Field

A free field above a reflective plane.

Semicircular Canals

The three sensory organs for balance that are a part of the cochlea structure.

Sensation Level (SL)

The level of a sound above the threshold of hearing for the same sound expressed in decibels.

Sensor

Any device that translates the magnitude of one quantity into another quantity. Three of the most common transducers used in vibration measurements are accelerometer, velocity transducer, and eddy current probe.

Sensorineural Hearing Loss

Hearing loss caused by damage to the hair cells of the cochlea or the auditory nerve.

Sequence (maximum length)

A mathematical sequence used in determining the well depth of diffusers.

Sequence (primitive root)

A mathematical sequence used in determining the well depth of diffusers.

Sequence (quadratic residue)

A mathematical sequence used in determining the well depth of diffusers.

Servo Force Balance Accelerometers

For measurements in the range of a few milli-g, with DC response, servo force balance accelerometers have long been the only practical instrument. They indirectly measure the amplitude of force necessary to balance the inertial forces on a proof mass caused by acceleration. Servo accelerometers have traditionally used electromagnetic effects to provide the balancing force, and measured the electrical current necessary to maintain the mass position stationary relative to the instrument housing, as the instrument accelerates. They usually use a very soft pendulous suspension for the mass, and are thus relatively fragile.

Servo System

An automatic feedback control system in which the controlled variable is the mechanical position, or any derivative of this parameter.

Shadow Zone

An area below which sound waves have bent upwards because of atmospheric conditions. Sound sources will not be as loud as expected.

Sharpness

A measure of the excessive high-frequency content in a signal. For example, white noise has more high-frequency level than pink noise and a higher sharpness value. It is more unpleasant to listen to. See also Aures Sharpness Calculation and Widmann Sharpness.

Shielding

The attenuation of a sound achieved by placing barriers between a sound source and a receiver.

Shim Machine

The machine whose position is changed during shaft alignment.

Shock

Rapid transient transmission of mechanical energy.

Short Time Fourier Transform

see STFT.

Side Lobe

When a weighting window is applied to a frequency domain function, side lobes can be seen on either side of the centre frequency. The dominance of these depends on the type of window in use.

Side-lobe Fall Off Rate

The rate at which side-lobes fall off, normally quoted in dB/decade.

Sideband

In frequency domain functions, pairs of frequencies with similar amplitude that appear equally spaced on either side of a centre frequency.

Signal

An electric voltage or current that is an analog of the vibration or sound being measured.

Signal Enhancement

If a part of a repetitive signal that has been identified by a trigger is averaged in the time domain, the signal is conserved while the additive noise cancels out. The main applications are waveform analysis, reduction of background noise, enhancement of orders, and separation of mechanical and electrical vibrations.

Signal Ground Coupling

Determines whether an acquisition front-end’s channels are earthed. Grounding sets a channel for single-ended grounding, while floating disconnects the screens and ground connections.

Signal Groups

User-defined collections of signals. A group can be treated as a single entity allowing the same measurement criteria and functions to be applied to each signal in the group in a single operation.

Signal Names

A signal name is the name given to a user-defined analysis channel. This name is user-definable, allowing descriptive names that represent the measurement situation to be used.

Signal-to-noise Ratio

The difference between the nominal or maximum operating level and the noise floor in dB.

Signals

To analyse a physical input, a signal must be defined on the (physical) channel concerned. A signal allows a number of different types of analyses to be made on the same channel with the same pre-processing applied.

Simple Harmonic Motion

A periodic motion whose displacement varies as a sinusoidal function of time.

Simulation Prediction

In structural dynamic testing, the ultimate goal of system identification is to create a dynamic mathematical model. This, in turn, may be used in simulations or to predict answers to specific questions.

Sine Wave

A signal that follows the path of a sine function. This can be a swept or have a fixed frequency. A sweep can be either linear or logarithmic. A periodic wave related to simple harmonic motion.

Single Degree of Freedom (SDOF)

A system where only one input can vary and is sufficient to describe the state of the system. SDOF systems are a very important concept for modelling structures, and often provide a sufficient model for a limited frequency band around a mode.

SISO (Single-input/Single-output)

This describes a model where only one degree-of-freedom is included. This is used in both dynamic and measurement models.

Slap Back

A discrete reflection from a nearby surface.

Smearing

This occurs when, for example, the speed of a machine is not stable while measurements are being made.

Sociocusis

Loss of hearing caused by noise exposures that are part of the social environment, exclusive of occupational-noise exposure, physiological changes with age, and disease.

SONAH

An abbreviation for Statistically Optimal Near-field Acoustic Holography, which is an implementation of Acoustical Holography not using spatial Fourier transforms. See also Acoustic FRF

Sone

A linear unit of loudness. The ratio of loudness of a sound to that of a 1 kHz tone 40 dB above the threshold of hearing. One sone is the loudness of a sound whose loudness level are 40 phons. Loudness is proportional to the sound's loudness rating, for example, two sones are twice as loud as one sone. The unit of measurement for subjective loudness.

Sound

Mechanical disturbance, propagated in an elastic medium, of such character as to be capable of exciting the sensation of hearing. The propagation of a sound wave can be measured in terms of the fluctuations in pressure with which it is associated. The measure of sound pressure is commonly the root mean square (RMS) value but may also be the instantaneous or peak value.

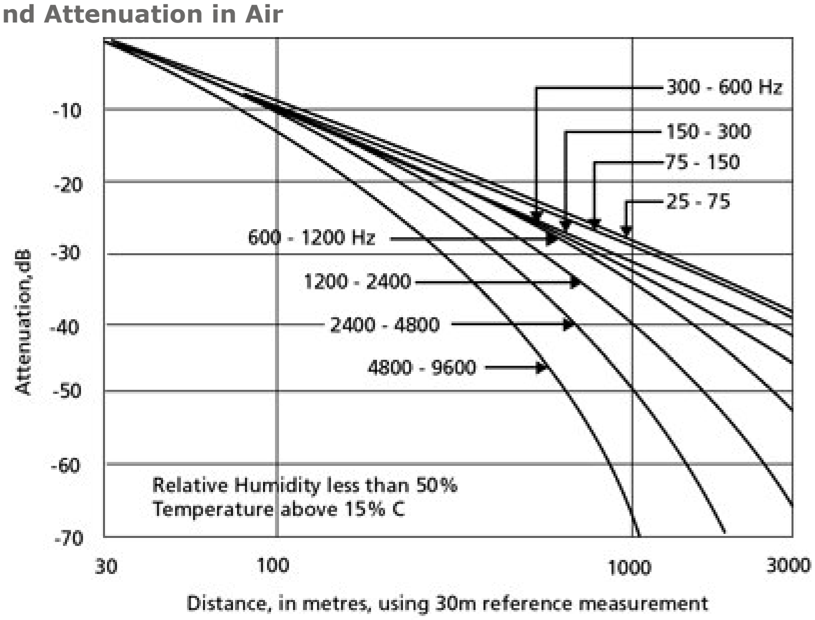
Sound Absorption

The product of absorption coefficient and surface area of a material. The unit is the sabin. Designates the amount of sound absorbed by a material.

Sound Absorption Coefficient

The practical unit between 0 and 1 expressing the absorbing efficiency of a material. It is determined experimentally.

Sound Attenuation in Air



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Approximate correction for air attenuation including the inverse square law.

Sound Concentration

The focusing of sound waves caused by reflections from a concave surface, or any other surface that focuses the sound waves in a specific direction.

Sound Exposure (E)

The quantity of sound impinging on the ear over an interval of time. It is directly proportional to the A-weighted sound intensity (that is, proportional to the square of A-weighted RMS sound pressure) and directly proportional to the duration of the sound. The SI unit is Pa^2.s and the practical unit for sound exposure meters is Pa^2.h. For a given duration, each increase of 10 dB(A) in sound pressure level corresponds to a tenfold increase in E. A sound of 85 dB(A) lasting for 8 hours (h) produces 1 Pa^2.h of sound exposure.

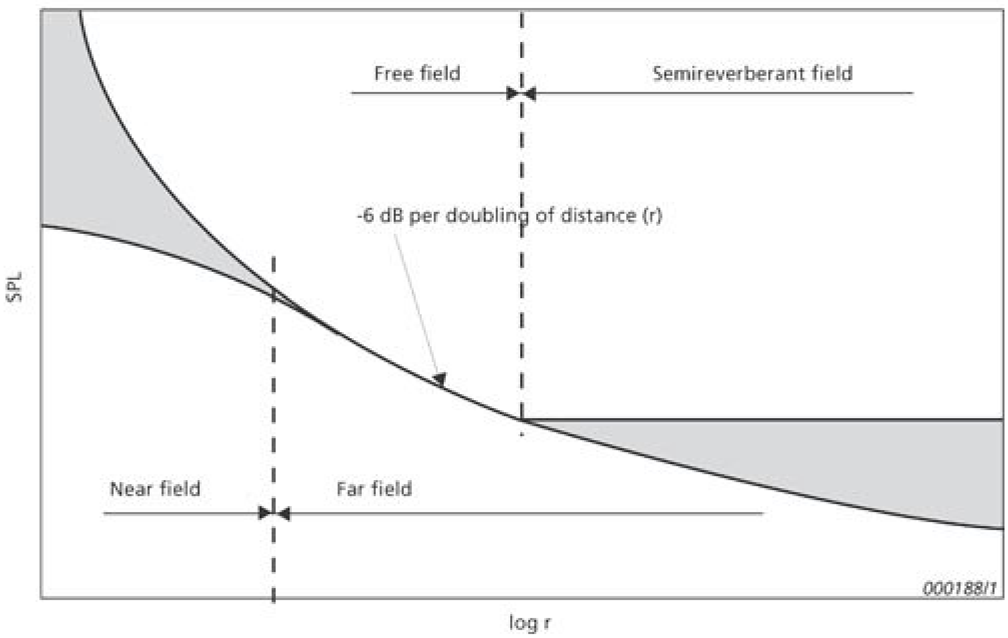
Sound Exposure Level (LEX, ref. duration)

The A-weighted sound exposure expressed in decibels relative to a reference duration. In the special case of constant noise that lasts for the reference duration, it is numerically equal to the sound pressure level (L_{eq}). Different terms have been used to define precisely the same quantity.

Sound Exposure Meter

A small instrument designed to be worn by an individual to provide a measure of the accumulated sound exposure received by the wearer while moving about during the workday. The instrument is calibrated in Pa^2.h. If the meter is worn for only a representative part of the working day, the reading must be corrected appropriately. Noise dosemeter (or dosimeter) is a more general term for instruments having a similar purpose but not necessarily measuring the physical quantity E or being calibrated in percentage of maximum permitted daily exposure and therefore can vary from country to country.

Sound Fields



The above graph illustrates the fundamentals of noise generation and propagation that must be kept in mind when measuring noise emission. In the near field, the shaded area shows that noise emission cannot be measured reliably. But further away in the far field, measurements are reliable and the level decreases 6 dB per doubling of distance (spherical spreading due to inverse square law) as long as the environment is effectively free field. When the environment becomes semi-reverberant due to reflections, which add to the level of the direct sound wave, noise emission measurements again become unreliable.

Sound Intensity

The rate of sound energy transmission per unit area in a specified direction. The product of the particle velocity and pressure; it is specified in units of power per unit area and is a vector quantity describing the level and direction of the acoustic energy.

Sound Intensity Probe

Used to determine the sound power. Brüel & Kjær's sound intensity probes consist of two closely spaced microphones. This enables the pressure gradient to be measured.

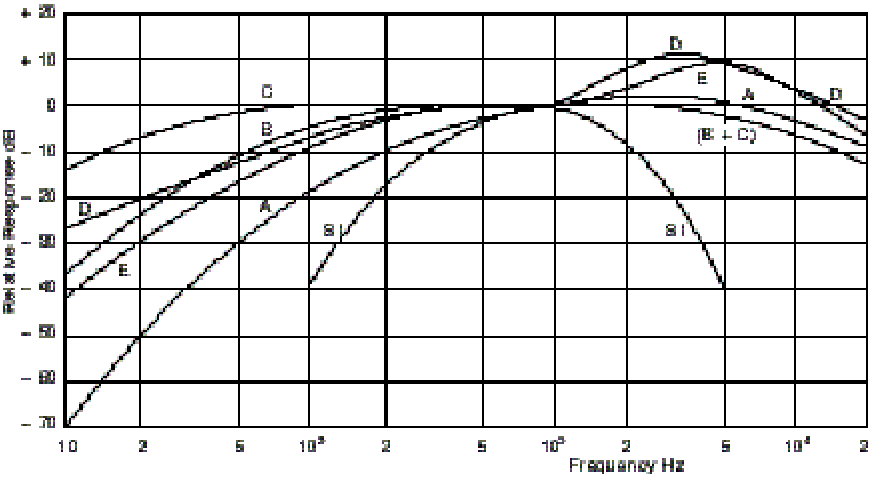
Sound Level

The weighted sound pressure level obtained by the use of a sound level meter and frequency weighting network, such as A, B, or C as specified in ANSI specifications for sound level meters (ANSI SI.4-1971, or the latest approved revision).

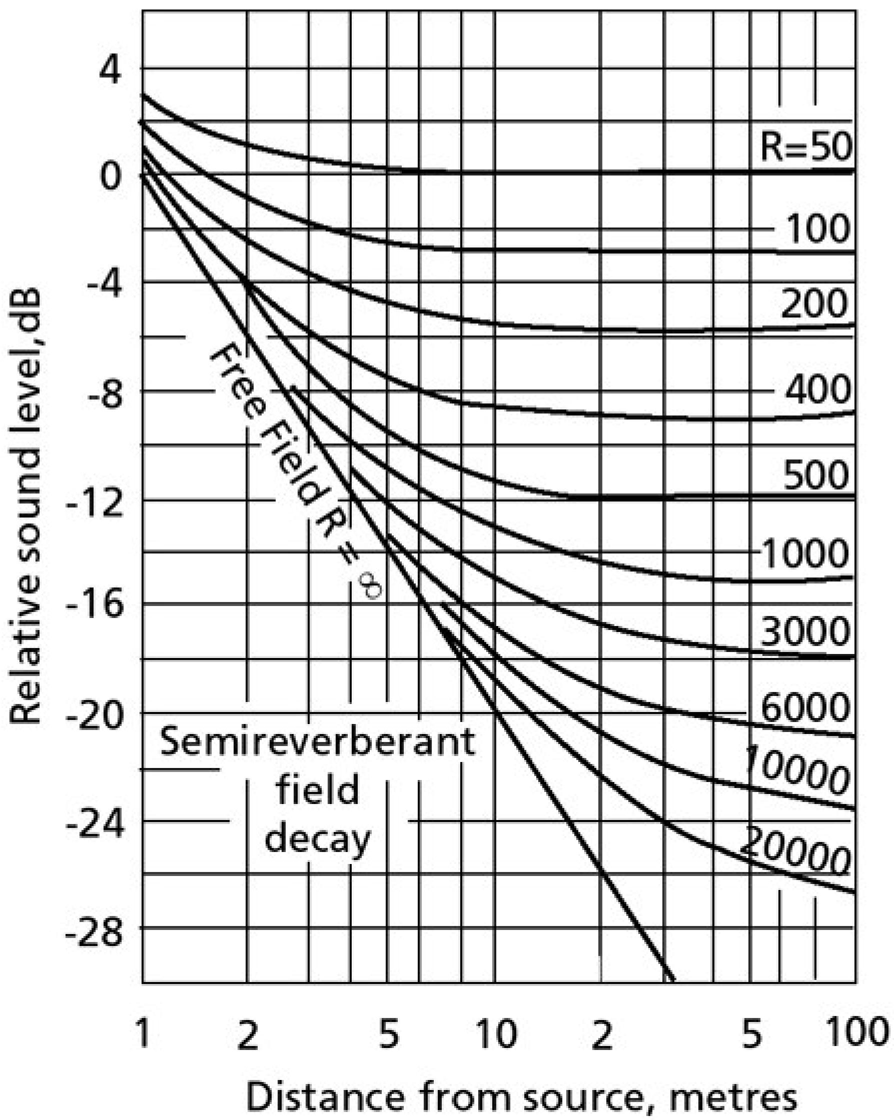
Sound Level Meter (SLM)

An instrument, usually hand-held, designed to measure a frequency-weighted value of the sound pressure level in accordance with an accepted national or international standard. It consists of a microphone, amplifier, square-law rectifier, averaging circuits and indicating instrument, having a specified performance in respect of directivity, frequency response, rectification characteristic, and time-weighted averaging. The instrument is normally equipped with F, S and possibly (time-weightings as an aid to measuring fluctuating sounds. With suitable circuitry it can also perform frequency analysis, typically either with octave or one-third octave bands. See also Integrating-averaging sound level meter, Time weighting.

Sound Level Meter Weighting Networks



Sound Level Prediction in Semi-reverberant Fields



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Sound Power

The total sound energy radiated by a sound source per unit time. The unit of measurement is the watt.

Sound Power Level (LW or PWL)

The level, in dB, at which a source produces sound energy per unit of time, usually given in octave bands. A power expressed in dB above the standard reference level of 1 picowatt. Sound Power Level = 10 $\log_{10}$ (W/W_0), where W is the emitted power and W_0 is the reference power (10^{-12} W).

Sound Pressure

The instantaneous difference between the actual pressure produced by a sound wave and the average or barometric pressure at a given point in space. A dynamic variation in atmospheric air pressure. It is a scalar entity describing the level of the sound pressure. At a point in a medium, the difference between the pressure existing at the instant considered and the static pressure. Sound pressure is measured in pascals (Pa), 1 Pa = 1 newton per square metre (N/m^2).

Sound Pressure Level (SPL)

Sound Pressure Level = 20 $\log_{10} (p/p_0)$ dB: The sound pressure level of a sound in decibels, is equal to 20 times the logarithm to base 10 of the ratio of the RMS sound pressure to the reference sound pressure 20 mPa (2×10^{-5} Pa).

Sound Quality Assessment

Consists of subjective and objective tests, and analysis. See Psychoacoustic Test Bench.

Sound Quality Metrics

Objective algorithms such as loudness, sharpness, etc., that are used to characterise sound quality.

Sound Spectrograph

An instrument that displays the time, level, and frequency of a signal.

Sound Transmission Class (STC)

A single-number rating system used to compare the sound-isolating characteristics of partitions used to separate occupied spaces. The preferred single figure rating system designed to give an estimate of the sound insulation properties of a structure or a rank ordering of a series of structures. Used to define sound transmission loss of a wall or partition. Expressed in decibels, it is 10 times the logarithm to base 10 of the reciprocal of the sound transmission coefficient of the configuration.

Sound Transmission Loss

Ratio of the sound energy emitted by an acoustical material or structure to the energy incident upon the opposite side.

Source Group

A group of related source points.

Source Point

A particular position (and in some cases, direction) on the structure where an excitation point is applied. The excitation is either a force (structure-borne contribution) or volume velocity (airborne contribution). Example: “Front Engine Mount Vertical 2Z-”.

Source Substitution method

A method of analysing airborne contributions, wherein a FRF matrix is used to estimate operating point source strengths. Also referred to as indicator method.

Source-to-Indicator Matrix

A matrix of transfer functions (H_{xv}) used to estimate operating source strengths from indicator operating data

Spacers

A generic term for any coupling that has 2 flex planes separated by a connecting shaft without bearings or other supports (between the flex points). Sometimes called an insert or spider.

Spatial Transformation of Sound Fields

see STSF.

SPC

Source Path Contribution

Specific Noise

Noise from the source under investigation. Specific noise is a component of Ambient Noise and can be identified and associated with the specific source. See also Residual Noise.

Spectral Lines

The number of constant bandwidth lines used in the measurement of spectra.

Spectrum

The spectrum is the result of transforming a time domain signal to the frequency domain. It is the decomposition of a time signal into a collection of sine waves. The plural of spectrum is spectra. Spectrum analysis is the procedure of doing the transformation, and it is most commonly done with an FFT analyzer.

Spectrum Analyzer

An instrument for measuring, and usually recording, the spectrum of a signal. A spectrum analyzer converts a signal from the time domain into the frequency domain, and the FFT analyzer is the most common type today, but there are many other types.

Spectrum Comparison

The display and examination of two or more spectrum for similarities between them.

Specularity

A term devised to express the efficiency of diffraction-grating types of diffusers.

Speech Audiometry

The presentation of speech material (usually word lists) to determine the percentage of material correctly received. In the simplest forms, listening is monaural by earphone in quiet to recorded material. Variations include live-voice presentation, free-field binaural listening, added noise, etc. In all forms, the speech level or speech/noise ratio is varied to plot a speech audiogram from which various measures are derived, principally speech reception threshold (level at which a defined percentage correct score is obtained, usually 50%), and optimum discrimination score (the maximum percentage correctly heard).

Speech Interference Level (SIL)

A calculated quantity providing a guide to the interference of a noise with the reception of speech. The speech-interference level is the arithmetic average of the octave band levels of the interfering noise in the most important part of the speech frequency range. The levels in octave bands centred at 500, 1000, and 2000 Hz are commonly averaged to determine the speech-interference level.

Speed of Sound in Various Media

	m/s
Air, 21°C	344
Alcohol	1213
Lead	1220
Hydrogen, 0ºC	1269
Water, fresh	1480
Water, salt, 21ºC	1520 at 3.5% salinity
Human body	1558
Plexiglas	1800
Wood, soft	3350
Concrete	3400
Mild steel	5050
Aluminium	5150
Glass	5200

Speed-related Component

Components in a spectrum that are dependent upon the speed of the object under test.

Speed (Velocity) of Sound in Air

344 m/s at 21°C (1128 ft/s at 70°F) in air at sea level.

Spherical Divergence

The condition of propagation of spherical waves that relates to the regular decrease in intensity of a spherical sound wave at progressively greater distances from the source. Under this condition the sound pressure level decreases 6 decibels with each doubling of distance from the source. Sound diverges spherically from a point source in free space.

Spherical Wave

A sound wave in which the surfaces of constant phase are concentric spheres. A small (point) source radiating into an open space produces a free sound field of spherical waves.

SPL

See Sound Pressure Level.

Splaying

Walls are splayed when they are constructed somewhat “off square”, that is, a few degrees from the normal rectilinear form.

SPR model

An SPC “template” representing the test vehicle (or part of vehicle) decomposed into source, receiver and operating condition points/nodes. During the course of testing and analysis, the model will be filled with data

Spring Constant of Materials (in compression)

$$k = \frac{E\,A}{l}$$

where:

- *E* = elastic modulus
- *A* = area of material
- *t* = thickness of material

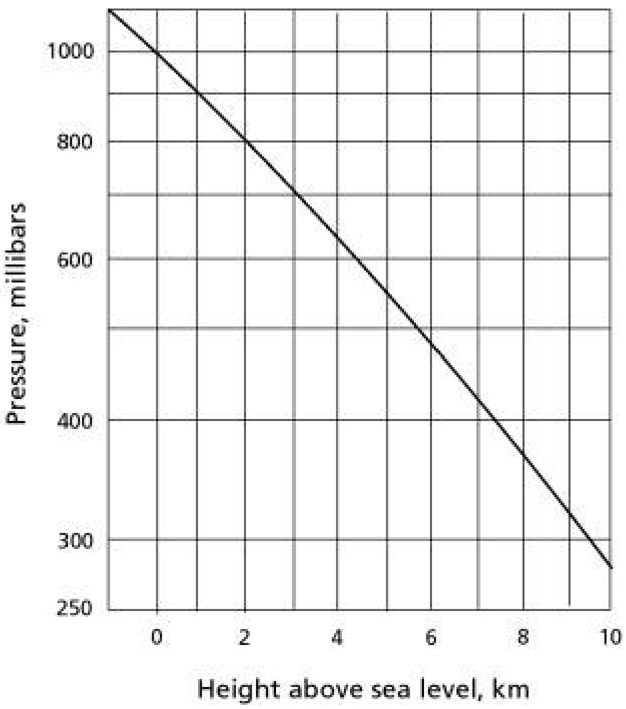
Standard Deviation

If the instantaneous distances from an equilibrium position of a vibrating body are squared and averaged, the result is called the variance of the vibration. The square root of the variance is the standard deviation. It is also equal to the rms (root mean square) value.

Standing Wave

A periodic wave having a fixed distribution in space that is the result of interference of progressive waves of the same frequency and kind. Characterised by the existence of maxima and minima amplitudes that are fixed in space.

Static Pressure vs. Altitude



Stationary Operating Condition

An Operation Deflection Shape is not unique in the same sense that a mode shape is. It is dependent on the operating condition and the choice of frequency and is thus only valid for one particular stationary condition.

Stationary Signal

A stationary signal is a signal whose average statistical properties over a time interval of interest are constant, and it may be deterministic or not. In general, the vibration signatures of rotating machines are stationary. Stationary signals are either deterministic or random.

Steady-State Sounds

Sounds whose average characteristics remain relatively constant in time. A practical example of a steady-state sound source is an air conditioning unit.

Stereo

A stereophonic system with two channels. See Binaural.

STFT (Short Time Fourier Transform)

Uses constant bandwidth analysis. This is preferable for vibration analysis applications.

Stiffness

Ratio of the change in force to the corresponding change in displacement of an elastic element.

Stiffness Matrix

In modal testing, this represents the coefficients of the restoring forces.

Stopband Frequencies

Frequencies that are outside those of the selected region.

Strain

Strain is defined as extension divided by original length.

Stress

Stress is defined as force divided by area.

Structural Integrity

This is achieved using modal parameter monitoring. The modal parameters of a structure are like a fingerprint. If a change in the structure occurs, for example, due to structural damage, it is instantaneously reflected in the modal parameters in terms of a change in the modal frequencies. Advanced techniques combining the mass or stiffness matrix data obtained from a finite element method analysis may be used to localise and quantify the damage.

Structural Modification

Mathematically determining the effect of changing the mass, stiffness, or damping of a structure and determining its new modal parameters. A modal analysis provides, in essence, a mathematical model of the structure. This model can be manipulated to determine the effect of modifications to the structure. The modal model can be generated either experimentally or using a finite element program.

Structure-borne Contribution

Vibrational noise from structure-borne sources (engine, gearbox, exhaust line, etc.) that is part of the total sound heard in a vehicle's interior

Structure-borne Sound

Sound that radiates from a construction assembly after travelling through a building's structure in the form of vibration.

STSF (Spatial Transformation of Sound Fields)

STSF uses scanned cross-spectrum measurements to create a graphical representation of a sound field. The main application areas are the automotive industry (engine tests, whole vehicles on dynamometers and tyre noise, domestic and industrial goods industries.

Sub Harmonic

Sub harmonics are synchronous components in a spectrum that are multiples of 1/2, 1/3, or 1/4 of the frequency of the primary fundamental. They are sometimes called "sub-synchronous" components. In the vibration spectrum of a rotating machine, there will normally be a component at the turning speed along with several harmonics of turning speed. If there is sufficient looseness in the machine so that some parts are rattling, the spectrum will usually contain sub harmonics. Harmonics of one-half turning speed are called "one-half order sub harmonics", etc.

Sub-synchronous

Frequencies in a vibration spectrum that are lower than the fundamental frequency.

Subjective Test

A sound quality test (either Semantic Differential or Paired Comparison) carried out by a jury who indicate their preferences for particular sounds.

Superposition

Many sound waves may traverse the same point in space, the air molecules responding to the vector sum of the demands of the different waves.

Sweep Random Vibration Test

A test in which a specimen is excited at a constant acceleration spectral density level in a narrow frequency band, the centre frequency of which is swept (varied) up and down.

Symbols (commonly used)

a(t)	(input) time signal
$\tilde{a}(t)$	Hilbert transform of a(t)
$\hat{a}(t)$	enhanced (input) time signal
$a_p(t)$	(input) time signal made periodic by FFT
A(f)	frequency spectrum of a(t)
$\tilde{A}(f)$	Hilbert transform of A(f)
$\hat{A}(f)$	spectrum of a(t)
$A_p(f)$	frequency spectrum corresponding to periodic input
A	amplitude
a	acceleration
A_0 - A_9	1k FFT spectra in 10k FFT zoom
B	bandwidth
b(t)	output time signal

B(f)	output Fourier spectrum
B_{3dB}	3dB bandwidth
B_{60dB}	60dB bandwidth
B_{Noise}	noise bandwidth
c	external sampling frequency/internal sampling frequency
c	damping coefficient
C_{80}	f_{80dB}/f_c
c	capacitance
$C_{AA}(t)$	(input) cepstrum
$C_{BB}(t)$	output cepstrum
$C_{AB}(f)$	coincident part of the cross-spectrum
D	decimation factor
f	frequency
Df	line spacing
f_s	sampling frequency
f_1	pitch frequency
f_{fund}	fundamental frequency
F	multiplication factor
f_{span}	frequency span of analyzer
f_N	Nyquist frequency
f(t)	force signal
F(f)	force spectrum
f_0	centre frequency
f_u	upper limiting frequency
f_l	lower limiting frequency
f_c	Cut-off frequency
f_{car}	carrier frequency
f_k, f_l	discrete frequency variable
f_{start}	sweep start frequency
f_{stop}	sweep stop frequency
$f_{real-time}$	real-time bandwidth
G(f)	glottis spectrum
$G_{AA}(f)$	(input) autospectrum
$G_{BB}(f)$	output autospectrum
$G_{AB}(f)$	cross-spectrum
$G_{AA}^L(f)$	liftered (input) spectrum
$G_{BB}^L(f)$	liftered output spectrum

$G_B^C(f)$	complex spectrum
$G_{VV}(f)$	coherent power
$G_{NN}(f)$	noncoherent power
G_{XiXj}	input cross-spectrum
G_{XiXi}	input autospectrum
G_{XiYj}	input/output cross-spectrum
G_{YiYj}	output cross-spectrum
G_{YiYi}	output autospectrum
H(f)	frequency response function
$H_1(f)$, $H_2(f)$, $H_3(f)$	different estimators of H(f)
h(t)	impulse response function
$h_1(t)$, $h_2(t)$, $h_3(t)$	different estimators of h(t)
I	sound intensity
I_r	sound intensity in the r direction
I_0	sound intensity reference
I_a	absorbed sound intensity
I_i	incident sound intensity
I_r	reflected intensity
k	stiffness
K	pressure intensity index
k	wave number
L_p	sound pressure level
L_I	sound intensity level
L_W	sound power level
m	mass
M	zoom factor
M(f)	input noise spectrum
m(t)	input noise signal
N	transform size
N_A	averaging number
n_1	line number for fundamental frequency
N_{span}	number of lines in f_{span}
n(t)	(output) noise signal
N(f)	(output) noise spectrum
N_x	number of input signals
N_y	number of output signals
p	sound pressure

p_0	sound pressure reference
p_A	sound pressure of the channel A signal
p_B	sound pressure of the channel B signal
P	sound power
P_0	sound power reference
p(a)	amplitude probability density of a(t)
q	number of bits
$Q_{AB}(f)$	quadrature part of the cross-spectrum
Q	quality factor
Dr	distance?
R	residue
R	resistance
$R_{aa}(t)$	autocorrelation function of a(t)
$R_{ab}(t)$	crosscorrelation function between a(t) and b(t)
r	radius
S_{ij}	power spectrum (instantaneous autospectrum)
S	surface area
$S_{AA}(f)$	two-sided (input) autospectrum
$S_{BB}(f)$	two-sided output autospectrum
$S_{AB}(f)$	two-sided cross-spectrum
S(f)	speech spectrum
S/N	signal-to-noise ratio
T	record length
T_A	averaging time
T_R	filter response time
T_{co}	cut-off time
Dt	sampling interval
T_1	pitch time
T_i	initial reverberation time
T_p	time period
t	time variable
t	temperature
T_0	$1/f_0$
t_i, t_m, t_n	discrete time variables
T_{AN}	analysis time
T_d	pulse duration
u	instantaneous particle velocity
u_r	instantaneous particle velocity in the r-direction

V	volume
v	velocity
v_0	velocity of hammer before contact
w(t)	weighting function
W(f)	weighting spectrum
x(t)	displacement
$x_i(t)$	input time signal (multi-channel analysis)
X(f)	displacement spectrum
$X_i(f)$	input Fourier spectrum (multi-channel analysis)
$y_i(t)$	output time signal (multi-channel analysis)
$Y_i(f)$	output Fourier spectrum (multi-channel analysis)
a	I_a/I_i
$D_1(t)$, $D_2(t)$	time signals consisting of d functions
$D_1(f)$, $D_2(f)$	frequency spectra consisting of d functions
g^2	coherence
e_1	G_{MM}/G_{UU} input error
e_0	G_{NN}/G_{VV} output error
e_r	normalised standard deviation
f	phase
F	phase or angle
$F(f_k)$	phase compensation
$r_{xy}{}^2$	correlation coefficient
r	mass density
z	damping ratio
s	decay rate
$s_x{}^2$, $s_y{}^2$	variance
$s_{xy}{}^2$	covariance
t	time constant
t	delay variable
h	loss factor
q	angle
w	angular frequency
w_0	undamped natural frequency
w_d	damped natural frequency
$[\ ]^2$	squaring
û	estimate
$\mathscr{F}$	Fourier transform

$\mathscr{H}$	Hilbert transform
$\mathscr{L}$	Laplace transform

Synchronised

Where two signals have the same period or one has a period equal to a multiple of the others.

Synchronous

Synchronous literally means “at the same time”, but in spectrum analysis, synchronous components are defined as spectral components that are integral multiples, or harmonics, of a fundamental frequency. They may in some cases exist as multiples of an integral fraction of the fundamental frequency, in which case they are called sub harmonics.

Synchronous Averaging

A type of signal averaging where successive records of the time waveform are averaged together. This is also known as time domain averaging. The important criterion is that the start of each time record must be triggered from a repetitive event in the signal, such as 1 rpm. The triggering assures that the phase of the waveform components that are synchronised with the trigger are the same in each record. Then in the averaging process, these in-phase components will add together while the rest of the signal components will gradually average out because of their random relative phases. The technique is excellent for extracting signals from noisy environments.

Tacho Line

The line that transmits the signal from the tacho input to start or stop a measurement.

Tacho Probe

A device for measuring the rate at which something turns.

Tangential Mode

A room mode produced by reflections off four of the six surfaces of the room.

TDS

Time-delay spectrometry.

TEDS

Transducer Electronic Data Sheet.

TEF

Time, energy-frequency.

Temporary Threshold Shift (TTS)

A temporary impairment of hearing acuity as indicated by a change in the threshold of audibility. The component of threshold shift which shows progressive recovery with the passage of time when the apparent cause has been removed.

Thermal Growth

Movement of the shaft centre lines associated with a change in machinery temperature between the static and operating conditions.

Thermal Profile

A secondary alignment method used to measure thermal growth. This method is only used for calculating the vertical thermal growth of the shaft centreline due to a change in temperature. The shim plane, under the machine feet, serves as a benchmark. This technique is usually used for machines under 500 HP. The technique uses the linear expansion equation where: Expansion in mils (E) is equal to the average change in temperature, °F (T) multiplied by the vertical distance from the shim plane to the shaft centreline, in inches multiplied by the coefficient of thermal expansion, in mils/inch °F. E =3D T × L × C. This is to be calculated for both sides of the bearing. The number of temperature readings is not critical, but at least four are recommended. The average change in temperature is between the offline and online temperatures.

Third-Octave Band

A frequency band whose cut-off frequencies have a ratio of $2^{1/3}$, which is approximately 1.26. The cut-off frequencies of 891 Hz and 1112 Hz define the 1000 Hz third-octave band in common use.

Third-octave Filter

A filter whose upper-to-lower passband limits bear a ratio of 21/3, which corresponds to 23% of the centre frequency. Is preferably centred at one of the preferred frequencies in ISO R266. Should meet the attenuation characteristics of IEC R266, IEC R255 and ANSI S1.11-1966 Class III.

Third-Octave and Octave Passbands

Band No.	Nominal Centre Frequency	1/3-Octave Passband	Octave Passbands
1	1.25 Hz	1.12 – 1.41 Hz	

2	1.6	1.41 – 1.78	
3	2	1.78 – 2.24	1.41 – 2.82 Hz
4	2.5	2.24 - 2.82	
5	3.15	2.82 – 3.55	
6	4	3.55 – 4.47	2.82 – 5.62
7	5	4.47 – 5.62	
8	6.3	5.62 – 7.08	
9	8	7.08 – 8.91	5.62 – 11.2
10	10	8.91 – 11.2	
11	12.5	11.2 – 14.1	
12	16	14.1 – 17.8	11.2 – 22.4
13	20	17.8 – 22.4	
14	25	22.4 – 28.2	
15	31.5	28.2 – 35.5	22.4 – 44.7
16	40	35.5 – 44.7	
17	50	44.7 – 56.2	
18	63	56.2 – 70.8	44.7 – 89.1
19	80	70.8 – 89.1	
20	100	89.1 – 112	
21	125	112 – 141	89.1 – 178
22	160	141 – 178	
23	200	178 – 224	
24	250	224 – 282	178 – 355
25	315	282 – 355	
26	400	355 – 447	
27	500	447 – 562	355 – 708
28	630	562 – 708	
29	800	708 – 891	
30	1000	891 – 1120	708 – 1410
31	1250	1120 – 1410	
32	1600	1410 – 1780	
33	2000	1780 – 2240	1410 – 2820
34	2500	2240 – 2820	
35	3150	2820 – 3550	
36	4000	3550 – 4470	2820 – 5620
37	5000	4470 – 5620	
38	6300	5620 – 7080	
39	8000	7080 – 8910	5620 – 11200
40	10k	8910 – 11200	
41	12.5k	11.2 – 14.1k	
42	16k	14. 1 – 17.8k	11.2 – 22.4k

43	20k	17.8 – 22.4k	

Threshold of Audibility (Threshold Of Detectability)

The minimum sound pressure level at which a person can hear a specified frequency of sound over a specified number of trials.

Threshold of Feeling

see Threshold of Pain.

Threshold of Hearing

The lowest level sound that can be perceived by the human auditory system. This is close to the standard reference level of sound pressure, 20 µPa at 1 kHz. The minimum level of a sound that is just audible in given conditions on a specified fraction of trials (conventionally 50%). In quiet conditions this is referred to as the absolute threshold. In the presence of masking sound or noise it is called masked threshold.

Threshold of Pain

120 dBA. The minimum sound pressure level of a sound outside the ear that will produce a transition from discomfort to definite pain.

Threshold Shift

A change in the threshold of audibility at a specified frequency from a threshold previously established. The amount of threshold shift is customarily expressed in decibels.

Timbre

An attribute of auditory sensation that allows a subject to judge that two sounds similarly presented and having the same loudness and pitch are dissimilar, for example, trumpet vs. violin. The quality of a sound related to its harmonic structure.

Time-delay Spectrometry

A sophisticated method for obtaining anechoic results in echoic spaces.

Time Frequency Analysis

When analysing non-stationary signals, time frequency analysis gives optimum resolution in both the time and frequency domains. Data is presented in a map with time shown on the x-axis, frequency on the y-axis and the amplitude indicated by various colors or greyscales in the contour map.

Time Weighting

The time-averaging characteristic used to measure oscillatory or fluctuating quantities. Common time weightings are rectangular (perfect integration with no memory) and exponential. Exponential weighting provides a running average in which recent values are more heavily weighted than those occurring earlier. Sound level meters have two conventional time weightings called F and S (called fast and slow in earlier days) with time constants of 125 and 1000 ms respectively. Some also have impulse time weighting which is a quasi-peak detection characteristic with rapid rise time (35 ms) and a slow decay. For measuring the true peak value of separated impulses which have fast rise times, the sound level meter must be equipped with a peak-weighting circuit having a time constant shorter than 50 microseconds.

Time Window

Fourier analysis tells us that time and frequency are simply two alternative ways of observing a signal. By changing the nature of a signal in the time domain, we implicitly change the nature of the spectrum in the frequency domain. This is exactly what we do when we apply a weighting function or "time window". A specified period of time record. Examples are rectangular, Hanning, Kaiser-Bessel, flat top.

Tinnitus

Ringing in the ear or noise sensed in the head. Onset may be due to an acoustic trauma and persist in the absence of acoustical stimulation (in which case it may indicate a lesion of the auditory system). Not directly due to external acoustic stimulation. It can be associated with exposure to high levels of noise.

Tolerance

The maximum permissible deviation from the specified quantity.

Tonal Metrics

The number of level tones that you want to measure and the block length of the frequency resolution.

Tone

A sound of definite pitch. A pure tone has a sinusoidal waveform. A tone results in an auditory sensation of pitch.

Tone Burst

A short signal used in acoustical measurements to make possible differentiating desired signals from spurious reflections.

Tone Control

An electrical circuit to allow adjustment of frequency response.

Tone-to-noise Ratio

The difference between the sound pressure level of a tone and the sound pressure level of the noise in a critical band centred on the tone, but in its absence. If the difference is greater than 6 dB, the tone is “prominent”.

Total Indicator Runout (TIR)

The total movement in mils of a dial indicator after a given rotation of a rotor.

Total Sound Power

The sound power level based on the total surface of interest (all sound power areas).

Trailing Edge

The part of a signal near the end of the time window.

Transducer

A device capable of being actuated by waves from one or more transmission systems or media and supplying related waves to one or more other transmission systems or media. Examples are microphones, accelerometers, velocity transducers, eddy current probes and loudspeakers.

Transducer Database

A built-in database that holds details on all transducers available and retrieves this information for use with the appropriate transducers in a configuration. The specifications for a transducer entered in the database should be taken from the transducer chart supplied. Calibration data is automatically stored in the transducer database.

Transfer Function

The output to input relationship of a structure. Mathematically it is the Laplace transform of the output divided by the Laplace transform of the input.

Transform

A transform is a mathematical operation that converts a function from one domain to another domain with no loss of information. For example, the Fourier transform converts a function of time into a function of frequency.

Transient

A rectangular window with adjustable starting point (shift) and duration (length). Samples inside the window are left unchanged, and the rest of the samples are set to zero. Use transient weighting to improve the signal-to-noise ratio when you analyse transients shorter than one time record.

Transient Signals

These are signals that start and stop within the analysis time (or measurement window). In most cases averaging is neither possible nor needed.

Transient Taper

The adding of half a Hanning window to the beginning and/or end of a transient window. The purpose of the leading and trailing taper is to reduce leakage due to truncation of the function or of noise. The length of the cosine tape is specified in Hertz.

Transmissibility

Ratio of the amplitude response of a system in steady state vibration to the excitation amplitude.

Transmission Coefficient

The dimensionless ratio of transmitted to incident sound energy from a single interaction between a sound wave and a partition. The value ranges from 0 to 1.

Transmission Loss

The ratio of the airborne sound power incident on a partition to the sound power transmitted by the partition and radiated on the other side.

Transmitting Directivity Index

A ratio measurement, at a point on the axis of the beam pattern, between the intensity generated by the projector and the intensity that would be produced by a non-directional projector radiating the same acoustic power.

Transmitting Voltage (or Current) Response

The ratio of the sound pressure apparent at a distance of one metre in a specified direction from the effective acoustic centre of the transducer, to the voltage applied across (or the current flowing into) the electrical input terminals.

Treble

The higher frequencies of the audible spectrum.

Trigger Hysteresis

Specifies a minimum percentage change of the trigger signal before triggering occurs, once the other trigger conditions have been met.

Trigger Level

The pre-set level at which a measurement is automatically initiated.

Tuneable Filter

A filter whose cut-off frequencies are adjustable, either manually or under remote electrical control.

Tympanic Membrane Displacement (TMD)

A technique for measuring very small (nanolitre) dynamic volume displacements of the tympanic membrane, such as those caused by respiration, cardiovascular activity, opening of the Eustachian tube or reflex contractions of the middle ear muscles. The measurement device incorporates a microcomputer controlled servo loop and employs ensemble averaging to improve signal-to-noise ratio.

Ultrasound

Sound at frequencies above the audible range, that is, above about 20 kHz.

Unattached Exciter

A technique in modal testing which uses direct excitation from an impact hammer.

Undamped Natural Frequency

The natural frequency of a structure.

Undersea Pressure

$P = A + 0.445\,D$

where:

- P = absolute pressure in psi
- A = atmospheric pressure in psi
- D = depth, in feet

$P = A + 10.0\,D$

where:

- P = absolute pressure, in kPa
- A = atmospheric pressure, in kPa
- D = depth, in metres

Underwater Acoustics

Speed of Sound in Water (The Leroy Equation)

$c = 1492.9 + 3(T - 10) - 6 \times 10^{-3}\,(T - 10)^2 - 4 \times 10^{-2}\,(T - 18)^2 + 1.2\,(S - 35) - 10^{-2}\,(T - 18)\,(S - 35) + Z/61$

where:

- c is the sound speed in m/s
- T is the temperature in °C
- S is the salinity in parts per thousand
- Z is the depth in metres

Accurate to 0.1 m/s for T less than 20°C and Z less than 8000 m.

Wavelength

$$\lambda = \frac{c}{f} = \frac{1521\text{m/s}}{f}$$

at 21°C and 3.5% salinity

Note: The speed of sound in water is about 4.4 times its speed in air. Therefore, the wavelength in water will be 4.4 times the wavelength in air at any given frequency.

Intensity Comparison to Air

$$\frac{I_{\text{water}}}{I_{\text{air}}} = \frac{\left(\frac{p^2}{\rho c}\right)\text{water}}{\left(\frac{p^2}{\rho c}\right)\text{air}}; \qquad \frac{(\rho c)\,\text{air}}{(\rho c)\,\text{water}} = \frac{1}{3570}$$

For an identical source intensity in water and air, the acoustic pressure generated in water will be about 60 times greater than in air. (r is the density).

Uni-directional

Only operates in one direction, for example, data can be either transmitted or received but not both.

Uniform

Uniform or rectangular weighting leaves the time window unchanged. Use uniform weighting to avoid leakage when you analyse periodic time signals repeating themselves an integer number of times within one time record. Uniform weighting gives the largest possible real-time bandwidth. The maximum picket-fence-effect error is 3.92 dB.

Uniform Window

In the FFT analyzer, the uniform, or rectangular, window does not modify the signal amplitude at all. It is also called rectangular weighting, or uniform weighting, and is selected when the signal to be analysed is a transient rather than a continuous signal. See also Hanning Window.

Update Criterion

The condition that when met, triggers the recording of the next set of data in a measurement.

Vacil

The unit of measurement for fluctuation strength. 1 vacil is the fluctuation strength of a 60 dB, 1 kHz signal with 100% modulation at 4 Hz.

Variable Capacitance Accelerometers

The Variable Capacitance principle of acceleration measurement is now being empioyed at Endeveco in their MICROTRON® Series accelerometers. The individual sensor element is micromachined from a single crystal silicon and then electrostatically bonded to form a parallel plate capacitive device. The result is a sensor which provides response to DC acceleration inputs, stable damping characteristics which maximise frequency response, and ruggedness to withstand extremely high acceleration overrange conditions. Integral electronics provide a high level low impedance output signal which is stable over temperature. MICROTRON is a low g accelerometer intended for applications such as trajectory monitoring, aircraft/vehicle structural evaluation, flutter testing, automotive suspension and brake testing, and other requirements for high accuracy measurement of low frequency accelerations.

Variable Sine

A sine wave that can have either, or both, a changing amplitude or period.

Vector Intensity

The component of the full microphone sound intensity in the probe axis direction.

Vehicle Bypass Noise

See Vehicle Pass-by Noise.

Vehicle Pass-by Noise

The total noise generated by a moving vehicle. This is usually measured according to a standard such as ISO 362 or SAE J1470.

Velocity

A vector quantity that specifies time rate of change of displacement.

Velocity Transducer

An electrical/mechanical transducer whose output is directly proportional to the velocity of the measured unit. A velocity transducer consists of a magnet suspended on a coil, surrounded by a conductive coil. Movement of the transducer induces movement in the suspended magnet. This movement inside the conductive coil generates an electrical current proportional to the velocity of the movement. A time waveform or a Fourier transform of the current will result in a velocity measurement. The signal can also be integrated to produce a displacement measurement.

Vibration

An oscillatory motion of solid bodies described by displacement, velocity, or acceleration with respect to a given reference point.

Vibration FRF

FRF in structure-borne contribution analysis (acceleration/force). Also referred to as VFRF.

Vibration Indicator

In structure-borne contribution analysis, the position where one measures to calculate operating forces.

Vibration Isolator

A resilient support for vibrating equipment designed to reduce the amount of vibration transmitted to the other structures. It reduces transmissibility.

Vibration Meter

An instrument for measuring oscillatory displacement, velocity or acceleration.

Vibration Severity

A criterion for predicting the hazard related to specific machine vibration levels.

Visco-Elastic

A substance is visco-elastic if it exhibits both viscous and elastic properties. This is in contrast to metals, which exhibit only elastic properties and negligible viscous properties.

Viscous Damping

Damping that is proportional to velocity. Viscous damping is used largely for system modelling since it is linear.

Voltage Preamplifier

A preamplifier with high input impedance that produces an output voltage proportional to the input voltage from a piezoelectric accelerometer. Input voltage depends upon cable capacitance.

Volume

Colloquial equivalent of sound level.

Waterfall

A 3D type of graph for the display of multi-spectrum. It displays the complete set of spectra measured over the period of interest and allows slices across the spectrum to be viewed. The x-axis is usually the frequency in Hz, or orders; the y-axis is amplitude, or level in dB; and the z-axis can be time, shaft speed (in RPM), crank angle or some other time-dependent parameter.

Watt (W)

The unit of electrical or acoustical power.

Wave

A disturbance that travels through a medium by virtue of the elastic properties of that medium. A regular variation of an electrical signal or acoustical pressure.

Waveform

The waveform is the shape of a time domain signal as seen on an oscilloscope screen. It is a visual representation or graph of the instantaneous value of the signal plotted against time. Inspection of the waveform can sometimes reveal information about the signal that the spectrum of the signal does not show. For instance a sharp spike or impulse and a randomly varying continuous signal can have spectra that look almost identical, while their waveforms are completely different. In machine vibration, spikes are usually caused by mechanical impacting, while random noise can be caused by the advanced stages of bearing degradation.

Wavelength

The normal distance between successive wavefronts of a sinusoidal wave propagating in a medium. For a periodic wave (such as sound in air), the distance between analogous points on any two successive waves. The wavelength of sound in air or in water is inversely proportional to the frequency of the sound. Thus, the lower the frequency, the longer the wavelength.

Wavelet Transform

Uses constant percentage bandwidth analysis. This is preferable for acoustics applications.

Weighting

Adjustment of sound-level meter responses to achieve a desired measurement or prescribed frequency filtering provided in a sound level meter. See also Window.

Weighting Curve

The hand-arm system has a frequency-dependent sensitivity. Measurement of the vibration signal must follow the same shape. This is similar to sound measurements, which must be include A-weighting to account for hearing sensitivity.

Weighting Network

An electronic filter in a sound level meter that approximates, under defined conditions, the frequency response of the human ear. The A-weighting network is most commonly used.

Weighting Window

Fourier analysis tells us that time and frequency are simply two alternative ways of observing a signal. By changing the nature of a signal in the time domain, we implicitly change the nature of the spectrum in the frequency domain. This is exactly what we do when we apply a weighting function or “time window”.

White Fingers

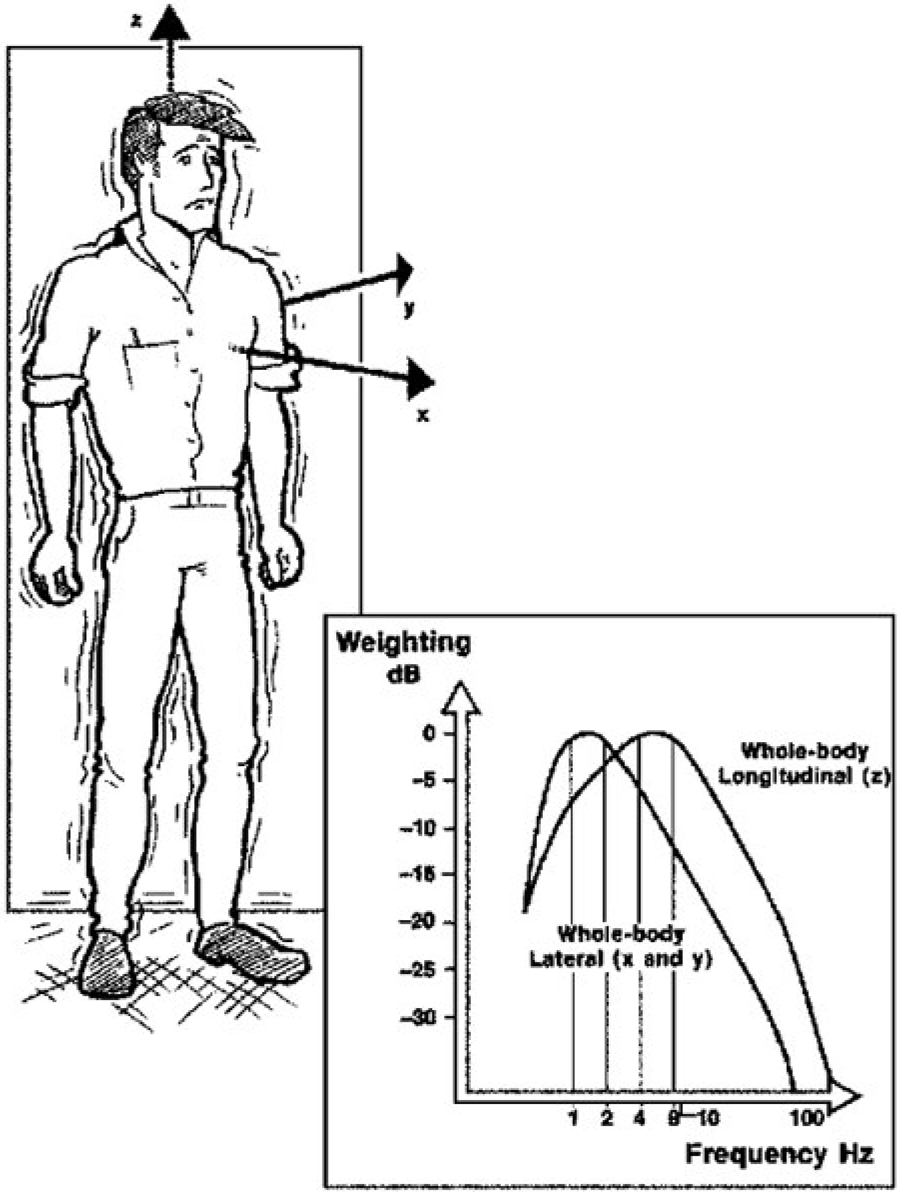
A disorder of the hands caused by using hand-held tools, such as chain saws and jackhammers. Results in reduction of the hand’s ability to feel or to regulate its temperature. May also result in numbness and excessive sensitivity to low temperatures. Called Raynaud's disease.

White Noise

Broadband noise having constant energy per unit of frequency. White noise sources can be used for calibration purposes. Analogous in spectrum characteristics to white light.

Whole Body Co-ordinate System

The co-ordinate system changes according to the orientation of the human body. The z-direction is along the spinal column of the body whenever the person is standing or sitting. The x- and y- directions are defined in the following illustration:



Whole Body Vibration

Vibration of the human body as a result of standing on a vibrating floor or sitting on a vibrating seat. Often encountered near heavy machinery and on construction equipment, trucks and buses.

Wide-band Random Vibration Test

A test in which a specimen is excited at a constant acceleration spectral density level at all frequencies simultaneously.

Widmann Sharpness

A method for calculation of Sharpness that is identical to that of Zwicker Sharpness except with a different weighting function. A low level compatibility correction introduces a dependency of the Loudness Level on the Sharpness value, especially at low levels. A threshold forces the Sharpness values in the individual bark bands to zero if the Loudness value is below the threshold.

Wigner-Ville Distribution

A general analysis technique that gives maximum resolution in both the time and frequency domains. It is used to examine a particular event in greater detail.

Window

The FFT analyzer does not operate in a continuous manner, but is instead a batch processing device, taking samples of the time domain signal and transforming them into a frequency domain spectrum. The time interval during which the signal is sampled and recorded is called the window. In order to compensate for certain limitations of the FFT process, the time data in the window are often multiplied by a weighting curve, such as a Hanning or Flattop weighting. These weighting curves are also called the Hanning window and the Flattop window respectively. See also Weighting.

Windscreen

A porous device used to cover the microphone of a sound level measurement system that is designed to minimise the effects of winds and wind gusts on the sound levels being measured. Typically made of open cell polyurethane foam and spherically shaped.

Z Transform

Applies to discrete time sequences and reduces the solution of an Nth order equation to find the roots of an Nth order polynomial in the transform domain.

Zero Pad

The samples in the second half of the time record are set to zero.

Zoom Analysis

Can be used in certain situations to obtain a much finer resolution, over a limited portion of the total frequency range.

Zwicker Loudness

A technique developed by the late Prof. Dr. E. Zwicker for calculating a real-time estimate for the loudness of sound as perceived by the human ear.