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Appendix 2

THE NATURE OF VIBRATION : BASIC CONCEPTS AND DESCRIPTORS

Introduction

This Section begins with a consideration of the nature of vibration, and of the terms and

parameters which may be used to describe and measure it, starting with the simplest, single frequency vibration and then continuing to more complex types.

Single frequency vibration

A vibration is a type of motion in which there is a to and fro oscillation about a fixed position. In the case of the simplest type of vibration the **displacement**, from the fixed position varies sinusoidally with time, t, and described mathematically by :

$$x = X.\sin t = X \sin 2ft$$

where X is the vibration amplitude, and is the angular frequency, in radians per second, equal to 2f, where f is the **frequency** of the vibration, in cycles per second, or **Hertz**. Frequency is the reciprocal of the **period**, T, of the vibration, which is the time taken for one complete cycle of the motion to occur.

$$\text{ie } f = l/T$$

The Root Mean Square value, RMS, of a vibration is given by :

where x(t) denotes that displacement x is a function of time, t.

In the case of a sine wave vibration where x = Xsin2ft, evaluation of the above expression shows that RMS = X/ ie that:

$$\text{RMS} = \text{PEAK} / = 0.7071 \times \text{PEAK}$$

In this case also, the **peak** value is the same as the **amplitude**, and the **peak to peak** value is twice the amplitude. A reduction by a factor of in terms of displacement corresponds to a reduction by a factor of 2 in vibration energy (compare with the relationship: sound intensity (sound pressure)^2) so that, for a sinusoidal vibration the RMS value is 3 dB below the peak value.

Displacement, Velocitv and Acceleration

Velocity is the rate of change of displacement, with respect to changes in time. During a complete cycle of the vibration the velocity also changes, through a complete cycle, as well as the displacement. Similarly acceleration is rate of change of velocity, and cyclic changes of acceleration will also occur during the vibration. These three cycles have the same frequency, but different amplitudes: X (displacement), V (velocity), and A (Acceleration).

Displacement, velocity and acceleration therefore give three different ways in which a vibration may be described and measured. The three are obviously related, and, for single frequency vibration, sinusoidal vibration only the relationships, between the three amplitudes are:

$$V = 2fX$$

$$\text{and } A = 2fV$$