PART TWO:

SHOCK

9. THEORY

Vibration is not the only potential source of dynamic damage for electronic equipment. Shock conditions are usually in different kind of tools used in extreme harsh enviroments, but they can also be experienced in conditions which are theoretically shock safe, due to misuse or drop.

9.1 SHOCK PULSES

Shock excitements are mathematically modeled as pulses, which are acceleration waves applied during short periods of time. There are several different theoretical pulses, each of them characterized by a different shape, such as square, half sine or triangular. In all cases the two parameters necessary are the acceleration level G and the duration of the pulse t_f. The frequency is calculated as

$$f = \frac{1}{2\,t_f}\ \text{(Hz)} \qquad (9\text{-}1)$$

The increase in velocity produced in the system is equal to the integration of the acceleration over time.

$$\Delta v = \int_{t=t_0}^{t=t_f} a(t)\,dt \qquad (9\text{-}2)$$

As in the case of vibration, the actual values of the parameters should be based on experimental data of the contidionts the system is expected to experience during its life. If it is not available, some guidance can be found in standards such as MIL-810.

9.2 PCB RESPONSE TO SHOCK PULSES

According to [1] printed circuit boards respond to shock with bending defformation in the direction of the pulse, followed by vibration at their resonant frequency. As usual, the fundamental frequency is normally the most prominent.

Although a proper analysis of a complex electronic structure is complicated, it is possible to approximate response characteristics using a single degree of freedom model. Especially good results are produced in the case of plug-in PCBs, where the rest of the structure can be neglected and test data shows [1] that most of the damage is produced by the fundamenta resonant frequency.

9.3 SINGLE DEGREE OF FREEDOM SYSTEM

When a single degree of freedom system is excited by a shock pulse, the system vibrates at its resonance frequency. The response will depend on the type of pulse, but in all cases the main parameter is the ratio R bewteen natural frequency of the structure and frequency of the shock pulse.

In the case of a half-sine shock pulse the isolation area lies where R is less than 0.5, in which it is possible to use a linear approximation of the shock amplification A

$$A = 2\,R \qquad (9\text{-}3)$$

Now the damping ratio is not as important as in the case of vibration analysis, since there are no resonance peaks as marked as before. As an example, the maximum shock amplification for a half-sine pulse when the damping is zero is 1.76.

The amplification can be used to obtain the maximum displacement expected using a equation similar to (7-2)

$$z_{max} = \frac{a_{max}}{\Omega^2} = \frac{A\,a_{max,input}}{\Omega^2} = \frac{4\,\pi^2 A\,a_{max,input}}{f^2} \qquad (9\text{-}4)$$

Although the actual value is different for other pulses, they are in the same range, both for the isolation area and the amplification.

9.4 MULTY DEGREE OF FREEDOM SYSTEM

As with vibration, electronic systems are usually modeled as two degree of freem systems, those being the electronic enclouse and the PCB. As usual, it is important to make sure that the two resonance frequencies are far enough to avoid amplification, since otherwise it is possible that the system presents high amplification. This usually translates into fulfulling the octave rule.

A little more detail into the analysis of two degree of freedom systems can be found in SHOCK ISOLATORS.