Damage Potential Spectrum DP(f_n) Software

A Descriptor for the degree of potential fatigue damage precipitated in products, due to variability of tables ,fixtures and product response.

What? The GHI Systems DP(f_n) software is a powerful new tool intended for vibration testing where a descriptor for the potential damage precipitated during the a is needed. The algorithm takes into account time, spectral excitation, and material characteristics. DP(f_n) can be used with typical normal (Gaussian) probability distribution shakers and, very importantly, can be used with “ESS, HALT, or HASS” chambers with pneumatic impactors, as defined later [1].

Why? For items with self resonances, the potential damage delivered during vibration tests having different power spectra is difficult to predict. DP(f_n) now makes this easy to determine. DP(f_n) can also be used to assess the effectivity of test fixtures for traditional as well as pneumatic impactor driven shakers. The software easily isolates the reasons why products end up with unknown or non-predictable fatigue when screened. The problem may be caused by fixture fidelity or table variability problems that cause unequal screening intensity. DP(f_n) provides a means to manage your test, giving direct comparisons of excitation damage potential. This is a powerful tool to insure that products are not over or under stressed, a ‘scatter’ condition that often results in product reliability problems.

Background GHI developed the first commercial PC Miners’s Rule based rainflow software known as Accumulated Fatigue Damage Factor (AFDF) for tracking fatigue rate on repetitive shock machines. AFDF has been adopted by “6DOF” screening chamber vendors as well as The University of Maryland’s CALCE Electronics Packaging Center. The DP(f_n) software is a direct extension of GHI’s expertise and the results of work performed to define the physical reasons for lack of low frequency smooth excitation inherent with repetitive shock machine chambers. It is a more correct predictor of fatigue accumulation since it is based on velocity spectra. Since stress is directly related to velocity and not acceleration, DP(f_n) is superior to the AFDF method. As a spectrum, it relates damage to the response frequencies of the components of the products under test, a valuable tool in ESS program management. It helps eliminate end of life scatter and variability.

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DP(f_n) Application Demonstration

Data recorded from sensors located on two PCB mounting studs six inches apart and on the table of an accelerated life test (HASS type) machine were used to produce DP(f_n) plots.

Figure 1 shows the DP(f_n)'s from both measurement points co-plotted for differential analysis. A cursor is located at an f(n) where a large difference in fatigue is occurring. The relative magnitude readout of DP(f_n) for the left fixture point as compared to the right fixture point shows a magnitude difference of 2.7 E+6 for 3600 seconds of excitation. The overlaid plots show zones that extend throughout the spectra with large amplitude differences, and in some cases where damage is higher or lower than the other fixture location. These ratios are the damage potential difference between the fixture mounting points, in terms of damage precipitated in the product under test.

Details of Process.

The reason that DP(f_n) can perform this role is that the algorithm includes methods that evaluate the factors effecting fatigue accumulation. The software is based on acceleration power spectra (PSD) so that accelerometers may be used, but since stress is related to velocity at resonance, certain modifiers are performed to establish equivalence with the velocity spectrum. The spectra are then further modified by values of component damping, S/N beta slope, and test duration. The result is the DP(f_n) spectrum, which is scaled in log magnitude per cycle.

For spectra that are stationary, the raw data recordings can be "snap shots" of the on-going process. In all cases, the user simply enters the total time of the test along with variables for damping and fatigue slope. A good value for damping is 5%, which is representative of average structures. For S/N beta, a value of 8 is recommended in MIL-STD 810. If actual product variables are different than those suggested, they should be used. The same variables should always be used during a test series or for any comparison test.

Simply put, DP(f_n) relates to the f_n of components, their damping, fatigue slopes, frequency, and the test duration. This is in close correlation with Miner's Rule. It differs from the earlier time domain AFDF in that DP(f_n) is in the frequency domain.

If the natural frequency, f_n ,of a specific component or a range of similar components is known, then highly accurate comparative estimates of damage potential can be easily made through direct comparison. If unknown, then frequency zones, where suspected problems exist, may be compared in relation to DP(f_n) amplitudes across those zones. In some cases, where no knowledge of f_n exists, the maximum value of DP(f_n) can be interpreted as the worst possible damage caused by that test.

If accumulated fatigue from one test to another, or from one form of excitation to another, varies the DP(f_n) differences will be apparent. The shape of DP(f_n) (i.e., it's peaks and valleys), will also predict which ranges of components at those f_n's will suffer the most, or least, damage. This makes overall correlation of screening results on products such as electronic circuit cards a simple matter.

[1] Henderson, G., Piersol, A., *Fatigue Damage Related Descriptor for Random Vibration Test Environments*, Sound and Vibration, pps, 20-24., October 1995.

Note: From the above reference, DP(f_n) results for repetitive shock machines will be valid for f_n's greater than four times the repetition rate of the pneumatic hammers since the machines produce primarily tonal excitation with little or no velocity or displacement at these low frequencies. For 50CPS or less hammers, this equates to approximately 200Hz. Above this frequency limit, DP(f_n) does have the same key strengths it provides for any type shaker.

Where to get more information:

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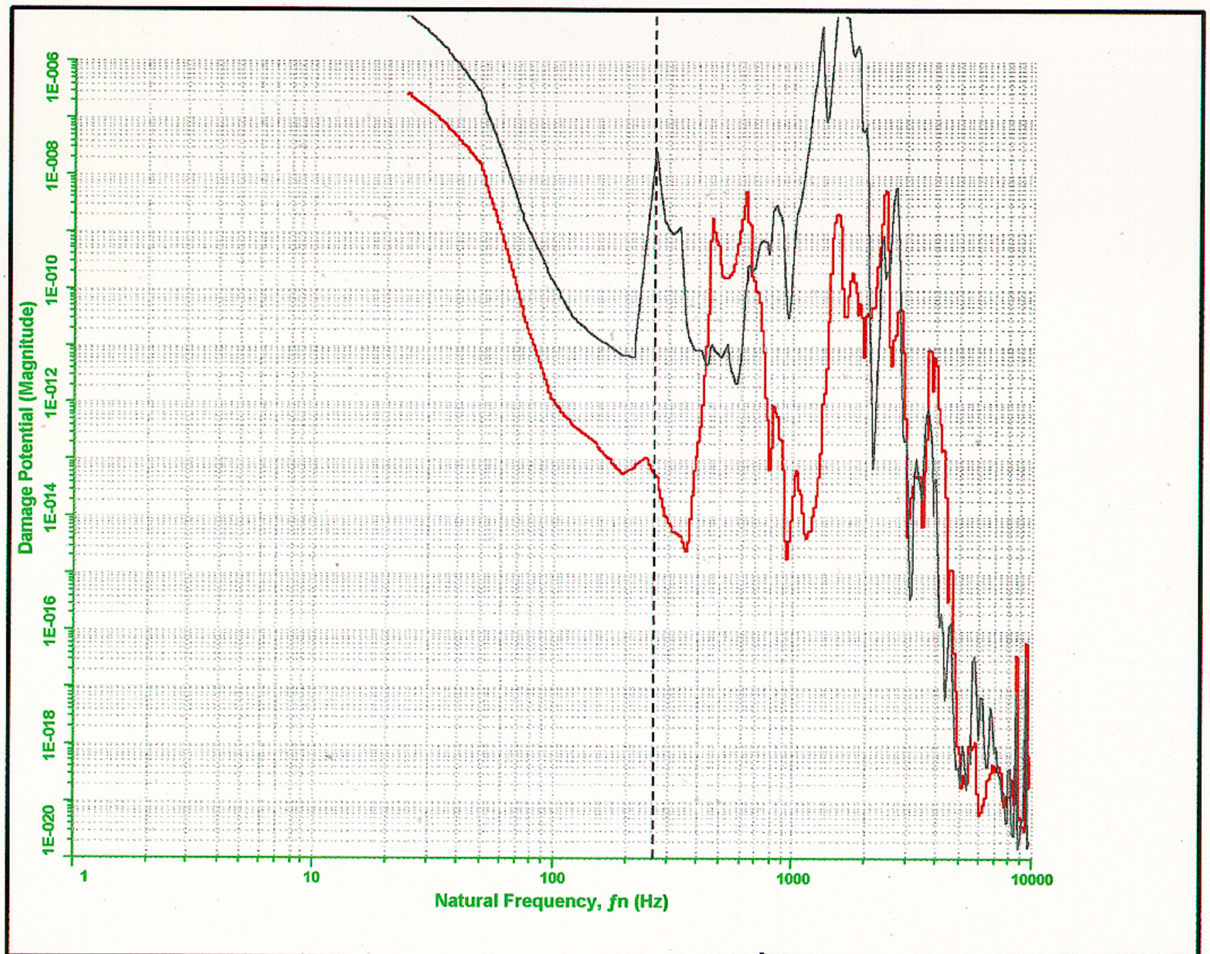
Comparative Fatigue Accumulation Display

Data from two adjacent product locating fixture positions.



Computing Mode	=	Damage Potential	Nat. Frequency	=	264.16 Hz
Source Channel	=	2	Amplitude	=	5.623E-014 Mag
Window Length	=	40.96 ms	Amplitude 2	=	2.034E-008 Mag
Duration	=	3600 s	Degrees Freedom	=	127
Damping	=	0.05			
Slope	=	8.0			

Figure 1. Dual DP(f) plots for two PC board mounting studs 6 inches apart. The cursor has been placed at an f(n) frequency. The DB(f) software lists the magnitudes of Damage Potential at this f(n) at the bottom of the plot. Note that there is a difference of 2.7 E+6 between the two studs at this frequency, and also that the magnitudes change greatly, even reversing magnitudes, above this frequency. Even without knowing the specific f(n) of a defective component, this display can determine if over or under testing has taken place.