# A New Random Vibration Recording Methodology: Sliding Window Overwrite Mode

**BY: Greg Hoshal**

**INSTRUMENTED SENSOR TECHNOLOGY, INC.**
**Okemos, MI**



## Introduction

In recent years small electronic data recorders have become widely used for measuring the random vibration environment in distribution transport packaging. Power Spectral Density(PSD) profiles generated from analysis on recorded vibration data can often be used for improved laboratory simulation of the actual field environments. However during most test shipments the digital recorders often do not have enough data memory to record the entire vibration time history of the shipment. Therefore some method of selective capture, or "sampling" of the vibration must be carried out.

Some commonly used triggering techniques for selective capture include time triggering or periodic sampling will fill/stop; time triggering with overwrite; event (amplitude) triggering with fill/stop; and event triggering with overwrite. In time or event triggered sampling with overwrite, the recorder simply accumulates the highest level vibration records over the entire ship test period, without regard to when the selected highest vibrations occurred. Using the standard overwriting approach it is possible for the data recorder to fill its memory entirely with data from a relatively small time period relative to the overall shipment time, and not have much information about shock or vibration during the other time periods of the shipment. A recently developed technique called Sliding Window Overwrite[1] (SWO) mode allows for a more uniform collection of highest-level data, while assuring that such data will be collected over all time portions of the ship test as specified by the user. In SWO a novel time dependency is introduced into the overwriting process. The time dependency allows a user to break up his test shipments into independent time periods with regard to overwriting. The result is recorded data which can be analyzed in a time interval or time segment basis much more effectively. Laboratory simulations based upon data collected using SWO will be more effective. This paper introduces this new recording methodology and explains how it can benefit the packaging engineer in random vibration test specification development.

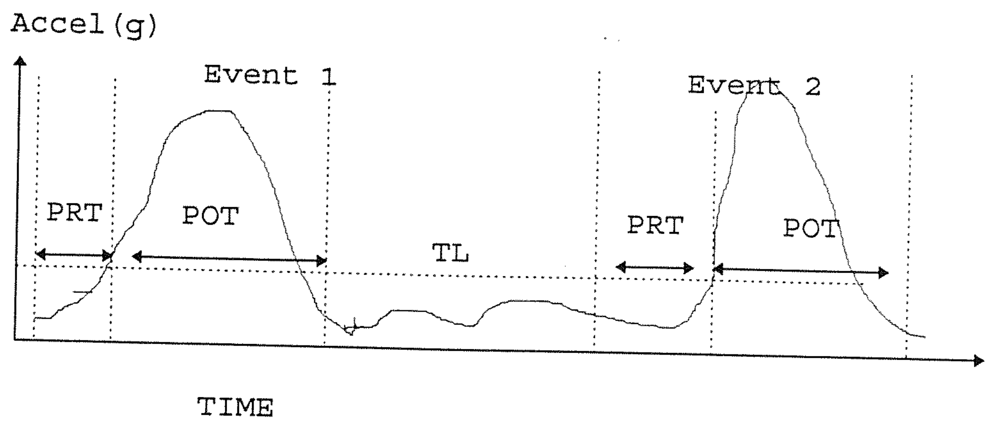
## A Review of Recording Modes for Digital Recorders:

### (A) Transient Capture: Amplitude Event Triggered Recording

In this mode the recorder will trigger and capture transient-type acceleration events only when a preset trigger g-level (TL) is exceeded on one or more measurement axes. A time-at-level threshold may also be used to capture only those transient events having a minimum energy content, as measured by velocity change. Shock or vibration waveform recording takes place by capturing a predetermined number of pre-trigger samples(PRT) as well as a predetermined number of post-trigger samples(POT). The sum of the two constitutes the recorded event and is carried out on all three measurement channels(or axes) simultaneously. Transient capture of events can occur repeatedly during field tests until the test is complete or until the memory becomes filled. Date and time is also usually stored along with each recorded event.

Transient capture recording is useful for recording events which occur randomly over time and with short duration, such as transportation and handling shocks, impacts or drops.

**Transient Recording**

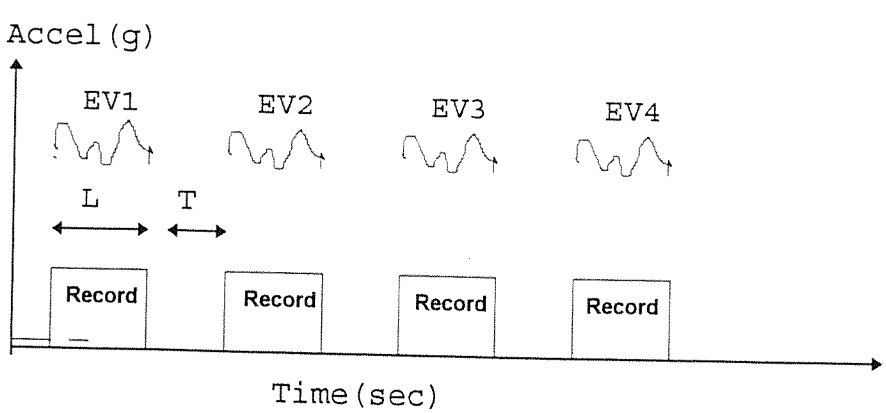



## (B) Time Interval Recording.

Time interval based recording provides predetermined recording of blocks of data spaced out over preset time intervals, (T). This technique is often used for sampling vibration data over long time periods. The user specifies a recording event length (L) and a time triggering interval (T) for setup. Recording of acceleration wave forms then occur at periodic, preset time intervals, and for preset duration.

Time interval recording is useful for recording relatively steady state type data over long time periods, where it may not be practical to record the entire process. Applications where time triggered recording is often appropriate include transportation vibration measurement.

**Illustration of**
**Time Interval Recording**



## Memory Modes: Fill&Stop, Overwrite, and Sliding Window Overwrite.

Since all available digital recorders have a limited data memory for event storage, it is necessary to have a method for managing recorded data if the memory should become filled before the field test is completed. Most recorders have at least two of the above three memory modes.

**Fill & Stop memory mode** selection causes the recorder to stop recording once the memory becomes filled. In some cases this may be acceptable, however in many instances it is possible to miss valuable field data if memory fills before the end of the test.

**Overwrite memory mode(OMM)** does not stop the recording process once the memory fills. It allows for continued recording of new event data which may overwrite or replace previously recorded event data depending upon an amplitude ranking criteria, and which is not event-time dependent. For OMM the user must specify a maximum number of events(M) selection. This selection must be determined based upon the amount of memory storage available in the recorder so that a total of M events may fit within available memory.

The recording method for OMM works as follows:

1. Event recording starts for events 1,2,3, ... up to M events during the test. The triggering method can be either transient capture, time interval, or mixed mode. During the recording of each event the recorder computes amplitude measures $a_1$, $a_2$, $a_3$, ... up to $a_m$. Appropriate amplitude measures are usually either a peak or an RMS g-level for each of the individual M recorded events.

2. The M+1 event is captured. The $a_{M+1}$ is computed.

3. A check of event amplitudes is then performed:

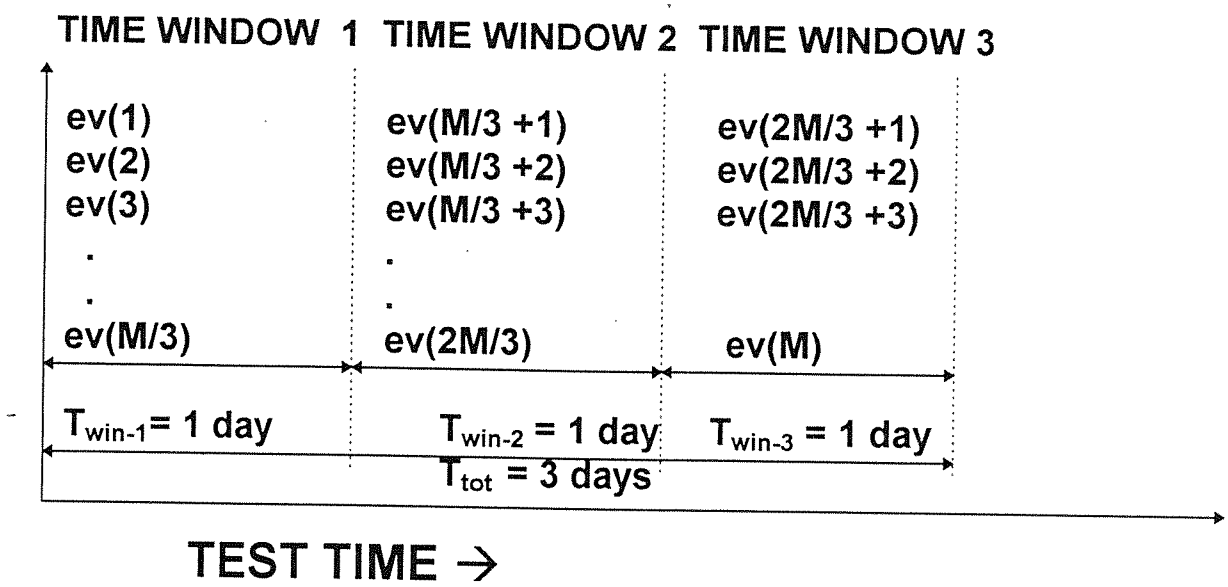
If $a_{M+1}$ is less than $\min(a_1, a_2, a_3, \ldots a_m)$ then M+1 event is discarded.

If $a_{M+1}$ is greater than $\min(a_1, a_2, a_3, \dots a_m)$ then event M+1 replaces the event which has $\min(a_1, a_2, a_3, \dots a_m)$.

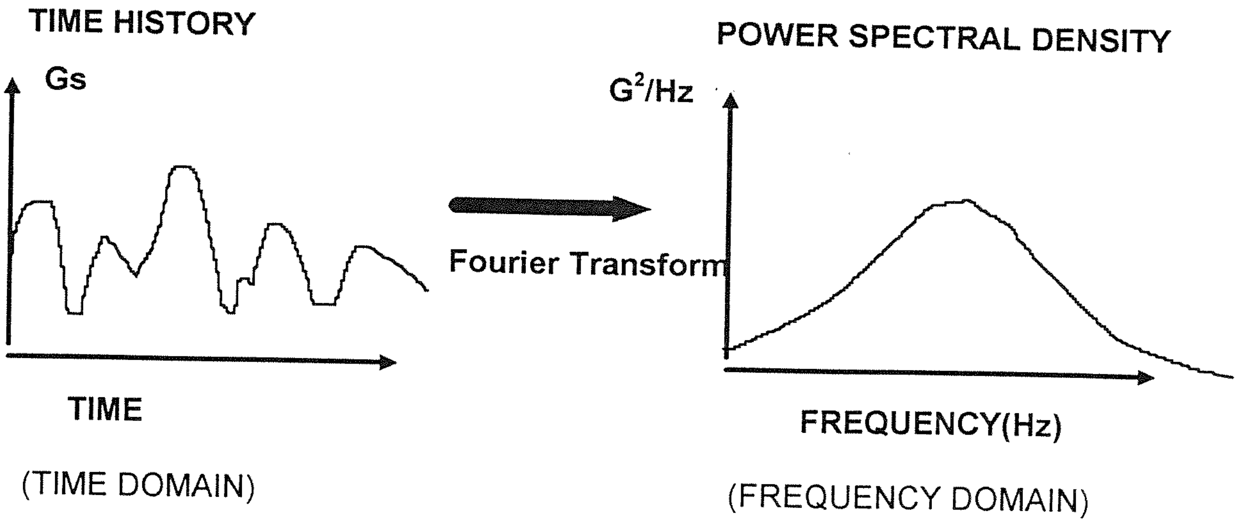
Recording continues in this fashion, whereby events having larger amplitude measures replace(overwrite) previously recorded events which have lower RMS amplitude. OMM enables the recorder to accumulate events which have largest energy content during the course of the field test, while not necessarily retaining all of the events which were triggered and captured by the recording. Overwrite mode allows for accumulation of "Worst Case" event data during a field test.

**Sliding Window Overwrite memory mode(SWO)** is a more sophisticated version of OMM. It also does not stop the recording process once the memory fills. It allows for continued recording of new event data which may overwrite or replace previously recorded event data depending upon an amplitude ranking criteria, and a time-of-occurrence criteria. For SWO the user can effectively partition or divide the shipment test time into a number of equal time intervals or time windows. Overwriting of one event over another can only take place for events which happen within the same time window. Once time exceeds a particular window, all events recorded in that time window are stored permanently and cannot be overwritten by future events in successive time windows. SWO has the benefit of recording "worst-case" or highest level data more uniformly for long field tests. SWO is particularly useful when performing vibration data recording over long periods of time, such as in transportation measurement, where the random vibration statistics may change significantly over time.

# Illustration of SWO for 3 Time Windows

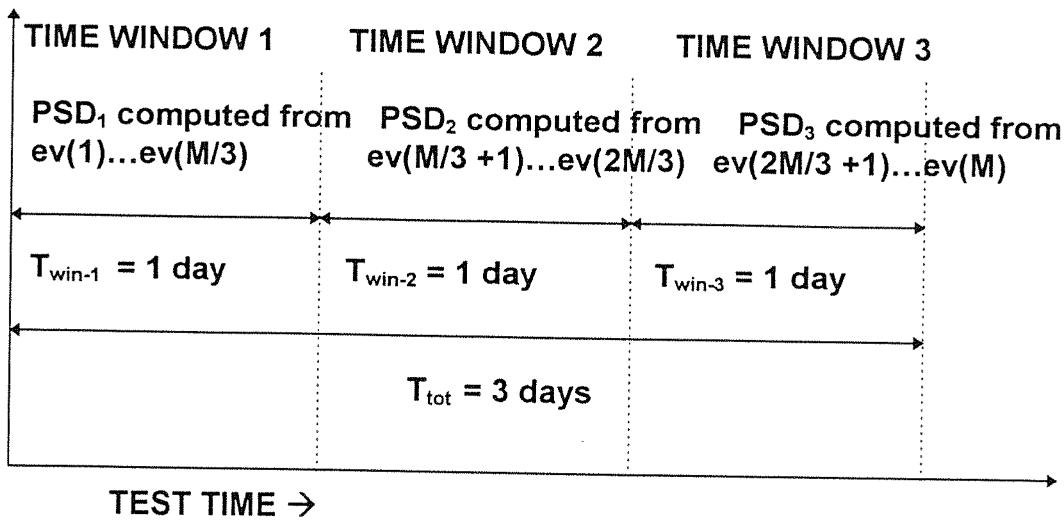


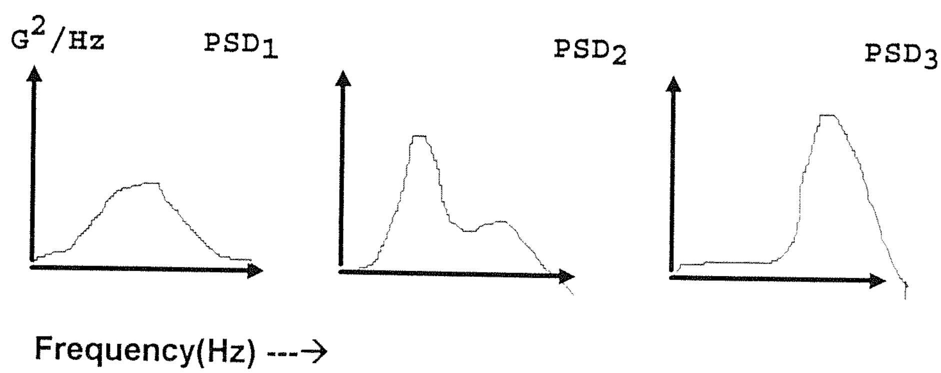

**Sliding Window Overwrite Mode- Applied to Random Vibration Measurement:** SWO has some particular advantages when applied to random vibration measurement. in cases of measuring vibration data over long time periods it is beneficial to partition the time periods of analysis so that individual PSD profiles may be generated for these time periods, rather than generating a single PSD profile averaging data over the entire test period. When a single PSD is used to characterize a long vibration process, the resulting average can sometimes give misleading results for simulation purposes. Portions of time when vibration levels were relatively high may actually appear significantly lower in an averaged PSD, than they actually were during the test shipment. In some cases this can make it more difficult to reproduce vibration related damage under laboratory simulation. SWO recording mode techniques offer improved vibration data collection and result in more realistic PSD-based simulations.




An illustration of how SWO can improve PSD test specification development is shown below. A hypothetical 3-day shipment is divided into three 1-day(24 hour) time windows. SWO enables the vibration recorder to capture the (M/3) highest-level vibration data records for each 24-hour period. The recorder holds a total of M vibration records at the end of the test shipment. All records are date & time tagged as well as time-window tagged. Using date/time separation an individual PSD can be computed from each respective set of (M/3) vibration time histories. The resulting PSDs provide a basis for simulating the highest rms level vibration data, independently for each one of the three 24-hour test shipment time periods. In some cases the PSDs may be significantly different, particularly if transport modes or conditions change from one day to the next.

# Illustration of PSD Analysis Using data from SWO For 3 Time Windows




**Laboratory Based Random Vibration Simulation-** One of the primary reasons for capturing field vibration data is to be able to analyze and reproduce the vibration data in a laboratory environment, often with the intent of reproducing field damage. With SWO the user now has the ability to perform more precise, time sequenced random vibration simulations, based upon data collected with known time dependency.

## Random Vibration Simulation From Data Captured Using SWO From Previous Illustration

**Run $PSD_1$ ' for time period T'** → **Run $PSD_2$ ' for time period T'** → **Run $PSD_3$ ' for time period T'**

Where $PSD_1$ ', $PSD_2$ ' $PSD_3$ ' are amplitude scaled up to account for a reduced test time T' less than $T_{win}$ used for vibration data recording.

## Summary

In this paper we have reviewed the different triggering and recording modes commonly used in today's digital recorders used for transport packaging vibration measurement. With this as a background, the recently invented Sliding Window Overwrite memory mode technique was introduced and explained. This new SWO approach enables users to collect subsets of [ highest-level ], or [worst-case] vibration data records within independent time intervals or windows. A new time dependency is introduced into the overwriting process.

The bottom line benefit to the package test engineer is better field data on which to develop PSD simulation specifications. Using SWO the engineer can get a broader measurement base for his field test, while still collecting [highest level] information. PSDs generated from data collected in this fashion can be time sequenced during laboratory simulation. The result is random vibration created in the lab more closely tracking the actual sequence of statistical variation in random vibration experienced by the product in shipment. Vibration related product field damage is more likely to be reproduced in a lab simulation based upon data collected using SWO. Company-specific Preshipment Test Specifications for vibration based on SWO are more likely to result in reduced field damage from vibration. All in all, SWO is a better way to collect your data when performing extended time field data recording.