Technical Note:

Definitions of AE Signal Measurements

Scope: This note reviews the definitions of AE measurements, specifically from the AMSY4. Comments on the differences between pure measurements and interpretation of measurements are included.

1. Introduction

AE Measurements are all taken from a one-dimensional time stream of digitized amplitudes in μV referenced to preamplifier input at each point in time in 0.1 μs steps. Units for AE measurements (and simple derivations of AE measurements) are voltage, time or combinations of voltage and time. Measurements can be interpreted to obtain other results, for instance the position of individual channels can be combined with arrival time differences between sensors to perform location analysis work.

2. Data Stored in Primary (.PRI) Data Files

Primary data files store characteristics from individual signals as processed by ASIPP boards. With each signal detected, the stored data set begins with the channel (CHAN) and a globally synchronized clock for all channels to 0.1 μs resolution (time components DAY=day of month, HH:MM:SS and MS.xxxx) for the first threshold crossing. The rest of this section describes other parameters which are stored or can be calculated from the data set.

2.1 Signal Measurements

AE signals have been traditionally reduced to 5 main attributes which are commonly called the AE parameter set. These parameters are counts, (peak) amplitude, energy, rise time, and duration.

As an example, from the transient signal at the left, the parameters measured are listed below.

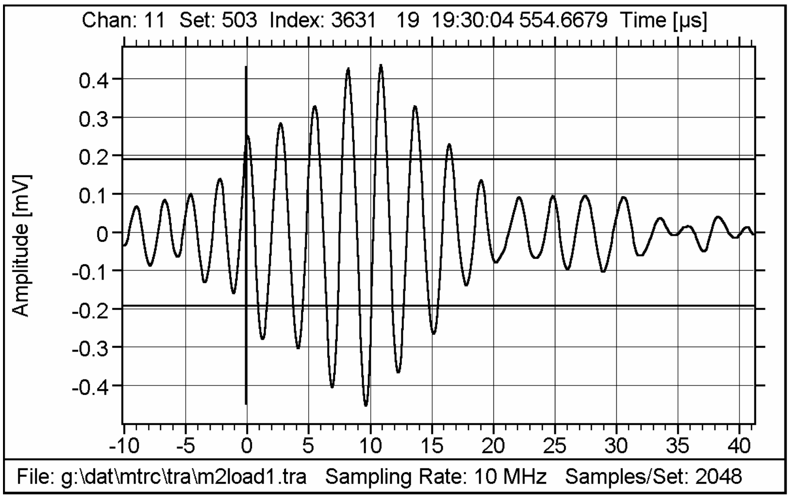

Figure Signal representative of a resonant response, Threshold = 45 dB_{AE} (0.2 mV)

CHAN	DAY	HH:MM:SS	MS.xxxx	CNTS	A [dB]	ALIN [µV]	E [eu]	R [µs]	D [µs]
11	19	19:30:04	554.6679	7	3.2	456	96E-1	9.6	17.0

The meaning of the variables in the above table are as follows:

In Table	Parameter	Description
CNTS	Counts	Number of positive threshold crossings (only upwards)
A ALIN	Amplitude in dB_{AE} Amplitude in μV	dB_{AE} = 20 Log (V_{preIn}/1 μV) V_{preIn}= Preamp. Input Voltage
E	Energy in energy units (eu)	1 eu= 10^{-18} Ws => 10^{-14} V^2s (True Energy) 1 eu= 1 nVs (Signal Strength Mode)
R	Risetime	1st threshold crossing to peak
D	Duration	first to last threshold crossing

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2.2 Measurements relating to Resolution of Individual Signals

Since the generation of AE events are asynchronous (some call this stochastic), the AE events do not always readily separate from one another, especially at high AE rates. The system requires directives to detect (the threshold = voltage level to trigger a hit) and separate (the rearm time is time below threshold required to reset hit trigger) discrete AE bursts. Crestfactor is a specified parameter that allows the threshold to "float." If the rms level times the crestfactor is greater than the fixed portion of the threshold, an effective threshold of (rms * crestfactor) is used. Note, if crestfactor is 0 the threshold is fixed. The duration discrimination time specifies to stop analyzing a signal if the signal remains below threshold for this period of time, so duration discrimination time must be ≤ rearm time.

Finally, the AMSY4 system makes two types of measurements which do not rely on the separation of individual hits. First is rms status events (RMSS). The AMSY4 will store the rms at each preamplifier input at the time interval specified, this measurement does not include AE above threshold. The second method is cascaded characteristics. The system continues to measure and store energy, counts and hits even if the rearm time criteria is not met. This data is stored in cascaded parameters. Additionally, individual cascaded hits are terminated every 100 ms, in this way, the cascaded counts per second, for example, represents all counts for each second and is not dependent on the rearm or duration discrimination times. The parameters discussed above include:

THR	Threshold at time of signal detection (interesting, if Crestfactor > 0, -> floating threshold)
HRMS	RMS level of the hit, calculated from energy and duration
RMS	RMS Noise level at preamp. input prior to the hit
CHIT	Cascaded hits in the hit-cascade (number of hits detected including during rearming)
CCNT	Cascaded counts in the hit-cascade (number of threshold crossings detected including during rearming)
CENY	Cascaded energy in the hit-cascade (accumulated energy including during rearming)

2.3 Derivation of Measurements

There are two quantities that are ratios of the basic parameters that are often useful. These are not stored in the data set but they may be used as any of the stored parameters:

FREQ	Counts per ms duration in kHz.
A/R	Amplitude/Risetime in $dB_{AE}/\mu s$ (also known as "Signal Slope")

The transient recorder data (.TRA file) can be used to derive still more parameters which are then stored in a transient feature file (.TRF) and not the PRI file. This file must first be generated (with Feature Extractor) and then be activated in multiplot. Classification features from VisualClass, AE pattern recognition software, can also be used in this way.

FMAX	The frequency at which the frequency spectrum has its maximum, in kHz.
FCOG	The frequency at which the center of gravity of the frequency spectrum occurs, in kHz.

2.4 Location Parameters

The Multiplot program provides several methods (location algorithms) to perform location analysis. A selected algorithm will define locations based on sensor positions and effective velocity, both given by the user, and differences in measured arrival times between sensors, which are measured. The location results (X, Y, ...) have the same units as distance and require as reference the positions of the sensors.

3. Transient Records

When a transient recorder is running along with the primary data acquisition, an index is created (sequentially increasing) for each TRA event stored. To correlate the PRI data to the TRA data, this index is stored in the PRI data and can be displayed as other data:

TRAI	Transient recorder index (points into *.TRA-file)

4. Summary

The many parameters that are stored, derived or interpreted have different usage. Understanding the definitions and motivations behind each parameter should be helpful in deciding when to use each.

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