

# Usage Autocorrelation Function in the Capacity of Indicator Shape of the Signal in Acoustic Emission Testing of Intricate Castings

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**Abstract.** The article contains information about acoustic emission signals analysing using autocorrelation function. Operation factors were analysed, such as shape of signal, the origins time and carrier frequency. The purpose of work is estimating the validity of correlations methods analysing signals. Acoustic emission signal consist of different types of waves, which propagate on different trajectories in object of control. Acoustic emission signal is amplitude-, phase- and frequency-modeling signal. It was described by carrier frequency at a given point of time. Period of signal make up 12.5 microseconds and carrier frequency make up 80 kHz for analysing signal. Usage autocorrelation function like indicator the origin time of acoustic emission signal raises validity localization of emitters.

## 1. Introduction

There are many pilofacturing holes and imperfections in structure of freight bogie. Stochastic signals with complex shape result of acoustic emission testing of freight bogies. Coordinates of emitters and transmitters of acoustic emissions have an overriding influence on the operation factors of signals.

Topicality: algorithms and methods of processing signal are very significant part of acoustic-emissions testing. Perfection of methods and algorithms raise validity of result testing.

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## 2. About autocorrelation function

The analysis objects are frequency, origins time and shape parameters of acoustic emission signals. Autocorrelation coefficient is on basis of calculating correlation coefficient by Pirson:

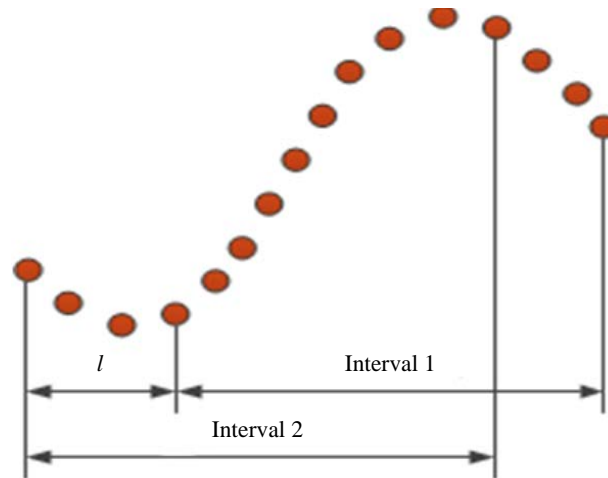
$$R_{j,l} = \frac{\sum_{k=0}^w (x_{k+j} - \bar{x}_1)(x_{k+j+l} - \bar{x}_2)}{\sqrt{\sum_{k=0}^w (x_{k+j} - \bar{x}_1)^2 \sum_{k=0}^w (x_{k+j+l} - \bar{x}_2)^2}},$$

where  $x$  – discrete acoustic emission signal, mV;  $j$  – sample of signal,  $w$  – summation interval;  $l$  – shift interval [1].

Function of autocorrelation was calculated for interval 1 and 2 with shift  $l$  (figure 1). Results of acoustic emission testing freight bogies were used in this work. It was received using the regular complex of acoustic emission control – digital acoustic emission diagnostic system SCAD 16.03 (Siberian Aeronautical Research Institute, Siberian State Transport University, Novosibirsk, Russia)



with gain factor 2000, discreteness ADC 0.5 microsecond – in West-Siberian railways repair car sheds.

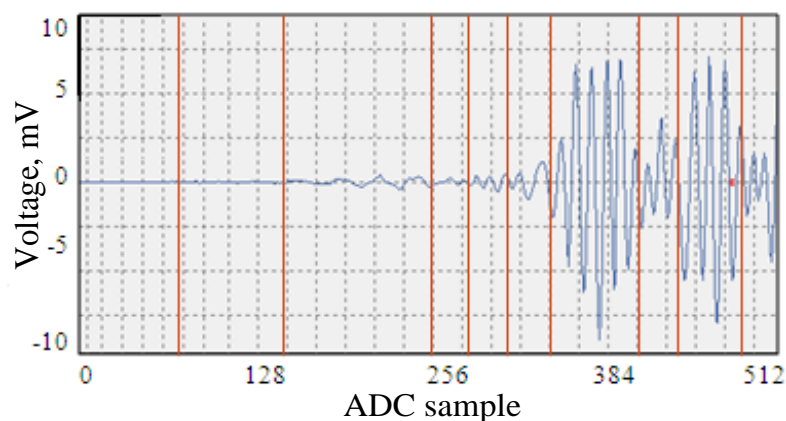


**Figure 1.** Scheme of summation intervals for calculating autocorrelation coefficient.

### 3. Determination of the operation factors

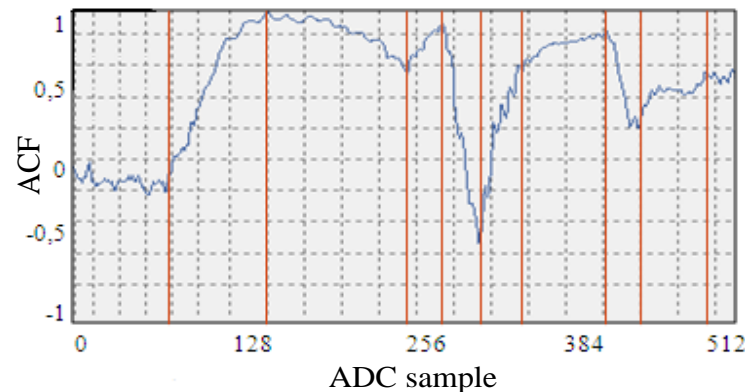
Modulus of autocorrelation function is approximately zero (below 0.2) before the origins time of signal. It happens on account of gears noises. Low-amplitude wave (below 1 mV) increase significantly autocorrelation coefficient (more 0.8). This pattern makes for increasing sensitivity of retrieval the origins time of signal with non-correlation gears noises [2].

Acoustic emission signal consist of different types of waves, which propagate on different trajectories in object of control [3]. Therefore shape of signal a lot vary with time (figure 2). Vertical lines mark turning points, which agree with confines of different parts in signal, on the diagram (figure 3).



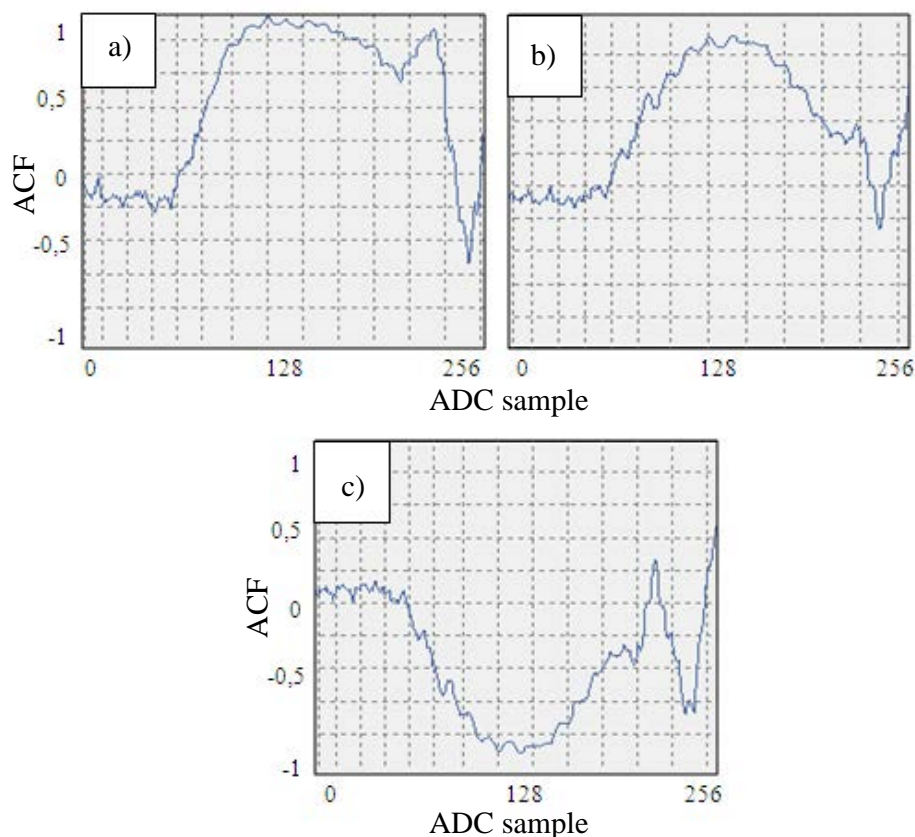
**Figure 2.** Acoustic emission signal.

Acoustic emission signal is amplitude-, phase- and frequency-modeling signal. It was described by carrier frequency at a given point of time. Evidently, autocorrelation function of interval 1 and interval 2 with shift  $l$  is periodic function.



**Figure 3.** Autocorrelation coefficient time relation with  $w = 64$  and  $l = 26$ .

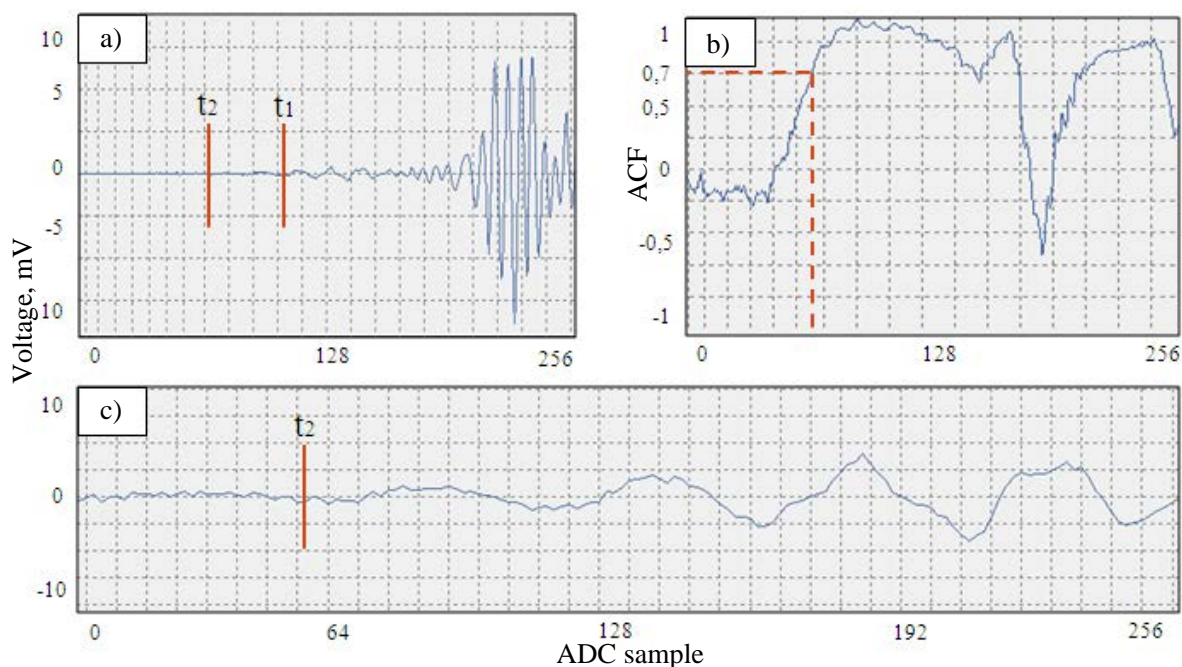
Autocorrelation coefficients with various shifts  $l > 0$  (figure 4) were calculated for searching typical period of signal. Period of signal (with ADC sample) was determined according to  $l > 0$  by which autocorrelation coefficient is maximal. If minimal autocorrelation coefficient fits half-period shift, then period was determined correctly [4]. Period of signal make up 12.5 microseconds and carrier frequency make up 80 kHz for diagram in figure 3. It fits the specifications of the transmitter.



**Figure 4.** Autocorrelation coefficient time relation with  $w = 64$  and  $l = 26$  (a),  $l = 51$  (b),  $l = 39$  (c).

Threshold-moving-window method isn't effective. Inadmissible error may appear when the origins time of signal  $t_l$  was determined (figure 5). Usage autocorrelation function in the capacity of origin

time of signal raise localization validity. Acoustic emission signal is superposition of stochastic non-correlated noise and impact part of signal [5]. Correlation coefficient more than 0.7 fits close coupling of values. Increase of coefficient autocorrelation indicates the origin time  $t_2$  of signal (figure 5).



**Figure 5.** Indicating the origin time of signal: a) acoustic emission signal, b) autocorrelation function, c) autocorrelation in zoom.

#### 4. Summary

In autocorrelation analysis basic operation factor is displacement of intervals. Intervals displacement is indicator which permits to calculate local value of carrier frequency. It is equal to 80 kHz. This value fits the specifications of the transmitter. Using autocorrelation analysis permits to select parts of signal with different form, which are justified different kind of oscillation in object of control.

Usage autocorrelation function like indicator shape of acoustic emission signal raises validity clusterization of emitters by dint of differentiation parts of pulse. Usage autocorrelation function like indicator the origin time of acoustic emission signal raises validity localization of emitters.

#### References

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