Verification of eCall unit parameters to describe the traffic accident seriousness

JOSEF MÍK, JANA KADLECOVÁ, PETR BOUCHNER
Department of Vehicles k616
Faculty of Transportation Sciences
Czech Technical University in Prague,
Konviktská 20, 110 00 Prague 1
CZECH REPUBLIC
mik@fd.cvut.cz

Abstract: The article deals with parameter verification for an eCall unit Black box type that can be further used to estimate the consequences of a traffic accident. As the unit is mainly designed to be installed into older types of vehicles, it only uses an internal accelerometer located on a printed circuit to identify the moment of collision, but this can affect the resulting acceleration measurement. A series of measurements is described in the article (crash test and a test on acceleration unit) during which the acceleration signal from an eCall unit is compared with the external accelerometer signal and the correlation analysis of both signals was performed afterwards.

Key-Words: eCall, crash test, correlation analysis, passive safety

1 Introduction

The requirements on vehicle safety rises also due to the rising number of accidents, the aim focuses on reduction of fatalities in accidents and reduction of the injuries caused. The all-Europe system of unified traffic accident emergency call was approved (further eCall), that allows to call for help from every car all-round the European Union and some neighbouring states, irrespective the states in which the accident actually happens. ECall system unifies range of sub-systems, linking of these allow to identify the accident occurrence and further inform the closest emergency centre. Development of paneuropean system eCall focuses on detailed enough description of the event so the emergency unit works the most efficiently. The foreseen launch of the paneuropean system eCall starts operation and units are installed in all newly produced cars, foreseen in April 2018.

The article deals with eCall type Black box parameters verification that further can be used for more precise estimation of accident results. The advantage of this kind of unit is the possibility to install it in older types of vehicles, which on the other hand, missing the signals of already installed passive safety features (e.g. airbag control units). In such a case the unit has to analyse the occurrence of an accident only from the internal signals coming from its sensors. To describe the accident and possible consequences in detail it is important to measure the eCall unit signals with high precision.

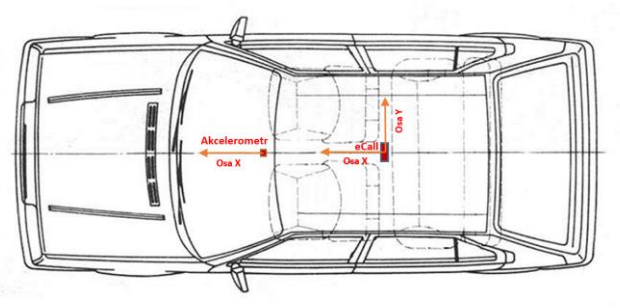
2 eCall unit description

The eCall unit that was used represents a complex system in which the whole eCall vehicle system is implemented in a single equipment (Black box). The advantage of such unit is the possibility of implementation into any vehicle. The unit can evaluate the intensity of the impact from signals of accelerometers in X and Y axes. The acceleration is measured by capacity accelerometer ADIS16204 that is implemented in the unit. The measurable maximum of lateral acceleration is 296 g. [1]

The emergency call starts as soon as the acceleration limit is reached, in the described case it was set to 5 g. In case of emergency call initiation, the unit stores the acceleration curves from the impact measurement in its memory. The unit allows to store up to 1024 values for each measured axis, sampling frequency 4000 values per second. Therefore, the unit can store the acceleration values for 256 ms. The recording starts 100 values before the acceleration limit is reached, it represents time interval of 25 ms. In case the acceleration limit for eCall initiation is not reached, the acceleration values are not recorded.

3 Verification of eCall unit parameters in impact test

In the scope of the impact test of Škoda Favorit against rigid barrier, the vehicle was equipped by a test version of eCall unit that allows us record the measured acceleration values. These values create the decision base for initiation of emergency call. The unit was located in the central tunnel of the vehicle, in the axis of the impact. The uniaxial accelerometer measured the acceleration of the car body in the X axis (in accordance with ISO 4130), as described on picture 1. To measure the car body acceleration, the eCall unit was equipped with Brüel&Kjær DeltaTrontype 4513-B accelerometer. The functionality of the unit as well as suitability of its parameters for assessment of accident severity was evaluated during the impact test.



Pic. 1: *Location of eCall unit and accelerometer in the tested vehicle*

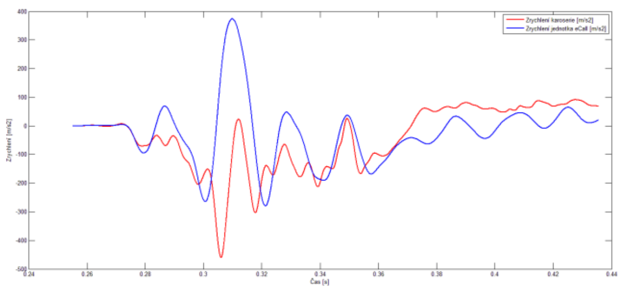
To state the dependence between the course of acceleration measured on the vehicle car body and the acceleration measured by the eCall unit in the vehicle X axis was performed via correlation analysis aiming to prove the close dependence of the two curves.

Before the correlation analysis of signals, the synchronization of signals in accordance with one timeline was performed as the first step. As the recording of measured acceleration in eCall is initiated after overpassing the 5g acceleration limit by an automated trigger, it cannot be directly read in the same timeline from separated accelerometer. The data is from the internal memory automatically sent to a server by means of data message. The courses of acceleration are compared in accordance with the first amplitude of signal that was measured by both the measuring systems and may be treated as the first impact signal. Both the signals were consequently filtered by frequency filter CFC 60. The resulting courses can be seen on picture 2. The already designed dependence between the acceleration values of both the signals was expressed by linear regression function stated in formula 1.

$$y=0{,}22\cdot x-12, \qquad (1)$$

in which: y acceleration value measured on the car body [m·s-2],

x acceleration value measured by the eCall unit [m·s-2].



Pic. 2: *Comparison of acceleration course measured by eCall unit (red curve) and by an accelerometer on the car body (blue curve)*

Final value of the correlation coefficient of the designed regression curve is r_{xy} = 0.22, therefore the correlation cannot be seen as tight.

4 eCall unit test on acceleration device

An alternative to verify the parameters of development unit eCall was the performance of a series of tests on the acceleration device that is depicted on Pic. 3. This device acts on a principle of falling device in which the hammer of the weight of 20kgs is pulled to the defined height and after the release of fixing tool falls by its own weight inside the leading tube. The height of the hammer at the initial stage of the test is measured by a rope distance gauge. Thick-walled cylindrical steel pot is located under the leading tube, from the top it is hermetically sealed by a circular lid. The whole pot is fixed on four vertical rods that allow it move it along a path of 0.5 m in vertical position. The leading mechanism enables the pot to be fixed in the uppermost position. If the pot is located in the upper position, the falling hammer hits the lid and transmits its kinetic energy. The fixing element is thus released, accelerated in vertical position and it falls down along the designed path. The landing of the pot is softened by a foam layer. [1]

Pic. 3: *Accelerating device used for eCall unit testing*

During the testing of the eCall unit, there was a series of tests aiming to verify the properties during the impact and the extent to which the unit itself measured acceleration. The eCall unit was fixed to the steel pot in the same way as during the impact test of the car. The acceleration in the X axis, corresponding the axis of the unit in the car, was measured. The acceleration course of eCall unit could have been continuously calculated and recorded without the use of internal memory of the unit. The eCall unit, as well as the uniaxial accelerometer Brüel&Kjær DeltaTrontype 4514-B was located on the steel pot. The accelerometer measured the acceleration of a pot in the same axis as the eCall unit. As both the measured acceleration signals were recorded by the same computer, they could have been synchronized by the same timeline.

There were 15 experimental measurements during the test, the falling height of the hammer on the steel pot with accelerometer changed. The set height was 0.24 m, 0.5 m and one control measurement of 0.4 m. The speed of the hammer falling on the pot can be calculated using the formula in 2.

$$v=\sqrt{(2\cdot h\cdot g)}, \qquad (2)$$

in which: v impact speed [m·s-1],

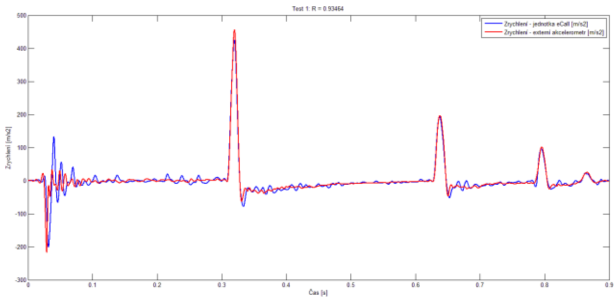
h initial height [m],

g gravitational acceleration ($g = 9.81\ m\cdot s^{-2}$).

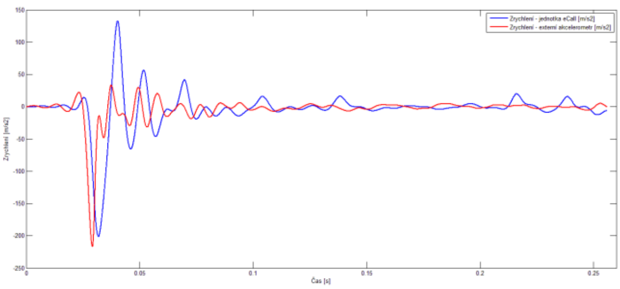
Further the data were processed in the same manner as in the case of eCall unit test during the real impact. The value of the correlation coefficient was calculated for the following three possible situations:

- Acceleration signals are synchronized by time and the complete course of fall is included (from acceleration to set at the bottom position),
- Acceleration signals are synchronized by time, their length is 256 ms (in accordance with the size of eCall unit memory),
- Acceleration signals are synchronized by the first amplitude; their length is 256 ms.

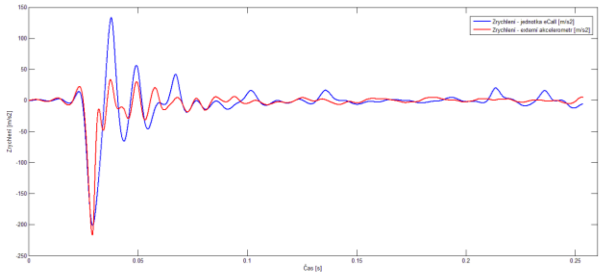
Examples of synchronized signals measured for the falling height of 0.24 m is described on pictures 4 to 6. In table 1 we can see the average values of correlation coefficients valid for the above mentioned assessments of acceleration signal measurement, divided according to the falling height of the hammer.



Pic. 4: *A complete course of acceleration measured by the eCall unit (blue curve) and by external accelerometer (red curve) during the test on acceleration device – time synchronization.*



Pic. 5: *A complete course of acceleration measured by the eCall unit (blue curve) and by external accelerometer (red curve) in time window of 256 ms on acceleration device – time synchronization.*



Pic. 6: *A complete course of acceleration measured by the eCall unit (blue curve) and by external accelerometer (red curve) in time window of 256 ms on acceleration device – synchronized by the first amplitude.*

Conclusion

During the eCall unit testing on acceleration device, it was proven that the repeatability of measurement of results showed higher statistical importance than the eCall unit testing during real vehicle impact test. The proper selection of the measurement methodology was confirmed by the similarity of course of acceleration, which were measured by eCall unit during the impact test and during the tests on the acceleration device. After the first amplitude of deceleration, which is comparable to the measurement of the external accelerometer, the signal changes for the reverse direction, but with much higher maximum than to the measurements by the external accelerometer. The resulting values of correlation coefficient, measured during the real impact test, showed low tightness than experiments with eCall on acceleration device. As depicted by the correlation coefficients in table 1, the higher the impact speed the lower the tightness of measured acceleration signals. The impact speed in this test was expressed as the speed of the falling hammer. Further reason for lower tightness of acceleration signals measured during the real impact test of the vehicle with eCall unit can be found in more sophisticated design links of eCall unit, external accelerometer and in more sophisticated course of acceleration applied too. Thanks to the progressive deformation of the car body parts.

During the impact test of a vehicle it was confirmed that the eCall unit operates properly. The unit well assessed the accident occurrence and started the emergency call after the acceleration measurement. Its reaction was adequate to the requirements that are commonly imposed on the eCall system. Regarding the measured acceleration parameters of the eCall unit, the sampling frequency of 4000 values per second is good enough for the unit. The capacity of the eCall unit memory is sufficient for recording of the 256 ms of acceleration signal from the frontal impact of a vehicle. The eCall unit is capable of recording the range of maximum acceleration values that occur during the car body deformation and influence the accident results greatly. The tested Škoda Favorit reached these values in the time range of 0 ms to 100 ms.

References:

[1] Bradáč J., Tulach P., Krejčí J., *Technical Note on Description of Impulse Vessel*, ToTS 2014/1, 2014, ISSN 1802-9876

[2] Mík, J., Kadlecová, J., *The use of information technology for vehicle frontal collision severity estimation*, Conference DCIS 2014, Děčín, 2014, ISBN: 978-80-01-05663-9

[3] Mík, J. Kovanda, J. Krejčí, J. Levý, J. *Evaluation of Rollover Unit eCall*. Croatian Journal of Education. ročník 14, str. 109 – 115, 2012. ISSN 1848-5650

[4] Mík, J., *Passive safety and influence of information technology*, doctoral thesis, Prague, 2015

[5] Mík, J., Rojdestvenskiy, D., *Use of eCall Unit Data to Estimate Accident Seriousness*, BSV, Ohrid, 2014, ISBN 978-608-65901-0-9