Whitepaper

# Application of AI vibration diagnosis for early detection of damage in car chassis

Application and benefits of AI vibration analysis for early detection of chassis damage in automated vehicle testing of the automotive industry


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## 1 Introduction

In conventional vehicle testing on bad roads, if something breaks (e.g. suspension parts, chassis, powertrain), the driver would have detected abnormal vibrations and noises through his own subjective sensitivity and decide whether a test should be interrupted for a detailed functional diagnosis. With the newly developed technologies of autonomous driving, vehicle testing is increasingly performed driverless and with automated test programs on test cycles.

With the lack of driver sensitivity, the need for measurement systems to detect changes in the NVH behavior of the vehicle chassis has grown in the automotive industry. The MIG16 EFD, a real-time, structure-borne noise based vehicle measurement system, was adapted for this task. red-ant received a patent for this innovative AI machine learning measurement method.

## 2 Operating principle of vehicle testing Early Failure Detection

Vibrations of the chassis structure were measured by accelerometers, digitized by the MIG16 EFD measurement system and recorded together with other driving information such as position and vehicle speed.

The vibration information is analyzed by classification of vehicle speed and GPS position information.

Limits are learned based on the vibration information and classification.

If a limit was learned in the analyzed class, MIG16 EFD compares the vibration level and other indicators to the limits and, if necessary, sends an alarm signal to the vehicle's drive control system.

Vibration energy (RMS), crest or spectral calculations can be used as vibration indicators.

### 2.1 Measurement setup

The measurement computer is mounted on the vehicle and the process is fully automatic. The MIG16 EFD starts with vehicle ignition and stops with ignition off. Vehicle speed and position are sent from the VCU to the MIG16 EFD. The measurement itself is triggered by the vehicle speed. An alarm signal is sent from the MIG16 EFD to the vehicle to stop the test cycle if something defective is detected.

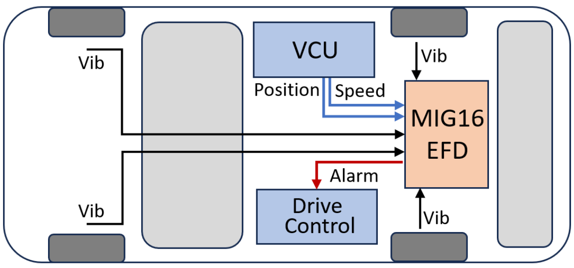



**Figure 1:** Measurement setup in vehicle

In order to control the MIG16 EFD, the operator can connect to the system from a remote location, for example via WIFI.

## 2.2 Measured values

The following signals are measured during a normal bad road track test of a vehicle:

- Vibration: 500g accelerometers mounted to the vehicle chassis, e.g. near the shock absorber mounts. The vibration signal is measured at a rate of 50 kHz and digitized at 24 bits.
- Vehicle Position: GPS information from the vehicle via CAN.
- Vehicle speed: information from the vehicle via CAN.
- Optional other values from the vehicle via CAN from other sensors via voltage signal.

## 2.3 Classification for AI Machine learning

It is necessary to classify the vibration behavior according to the vehicle speed and the vehicle position on the test track, because the vibration behavior of a vehicle on a test track depends significantly on the stimulation of the surface structure and the vehicle speed. It is also possible to use additional other values for the classification.

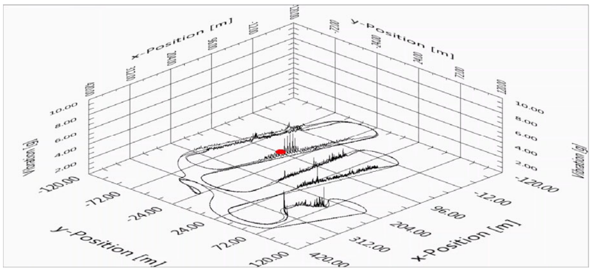
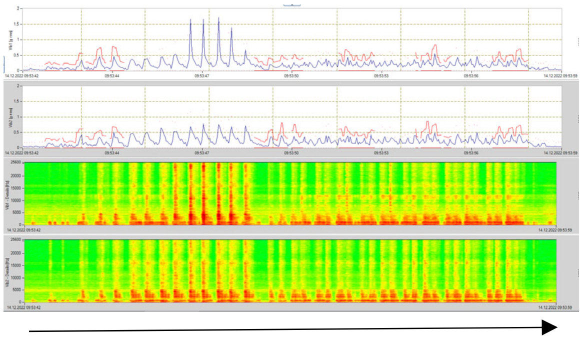



**Figure 2:** Vibration energy, depending on the vehicle position, due to bad road sections in the track.

## 2.4 Failure detection

If, after several miles of bad road testing, a component, such as the suspension, fails and the vehicle is driven over a significant bump, the unusual vibration is detected by the MIG16 EFD system and a pre-alarm is generated. A software process (the MIG16 EFD Alarm Manager) filters the pre-alarms and if the pre-alarm is plausible, a shut down alarm is given to the VCU. With the shut down alarm, the vehicle can then leave the track according to the safety procedure and proceed to the repair area.

The vibration indicators can be analyzed in post-processing by an operator in addition to the real-time analysis of the MIG16 EFD. All indicators such as intensity and spectral information of each sensor can be used to specify the fault that caused a shutdown in detail. The signals can also be replayed as audio stream using the EasyReporting tool.



Test track in meters

**Figure 3:** Vibration analysis of a section of a test track. Above the vibration energy of two sensors with their limits, below the corresponding spectral analysis.

# 3 Summary

With the MIG16 EFD and four accelerometers mounted on the chassis, the driver's subjective NVH sensitivity is replaced by an objective measurement system. With the MIG16 EFD installed in the test vehicle, the test is interrupted if abnormal vibrations occur during the test procedure and major consequential damage can be prevented.

With the MIG16 EFD software, every defect is documented in terms of its development time and appearance, and the unique multi-sensor design makes it easy to diagnose where the defect occurred in the vehicle.

With this automated early failure detection, the test track can be automated with up to 10 vehicles running on the track at the same time, without the risk of one vehicle failing and ruining the test for the other vehicles.