# Noise diagnostic possibilities on electric powertrains

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Abstract: The aim of this research is to find out the correlations between the faults of a vehicle and noises of the vehicle and offer a method to do the evaluation. It is just an initial step towards a potential big research.

We survey the possible tools, problems, methods and make the necessary equipment, make settings, and make some test measurements, draw conclusions and determine the additional steps needed with our accumulated experience.

There are existing methods which are analysing vibration and acoustic sound to figure out are there any devices in the vehicle which are having mechanical faults. [4] They could be further developed. It is also a possible way to implement noise based self diagnostic systems in vehicles.

## 1. 1. INTRODUCTION

### *1.1 Noise diagnostics in automotive industry*

The main reason that noise diagnostic can be a good base measurement for vehicle diagnostic that is a contactless measuring method, so the measuring system is not is touch with the measured or controlled part of the vehicle.

In electric drivelines there are so many possible failures that can emit noise. For example: imbalance, eccentricity, axle bending, clutch failure, excessive wear of plain bearing, lubrication failure, rolling bearing failures, gear failures, gear problems, chain drives failures, belt drive failures, pump failure, pump failures, pump failures, pump failures, and gas flow problems.

In the manufacturing industry noise measurement is used for the accurate estimation of maintenance requirements of machines. Deterioration can be tracked by observing signal degradation relative to the reference value.

It is also possible to share the measured values on the communication network of the car so it is possible to get correlation between different measuring type sensors.

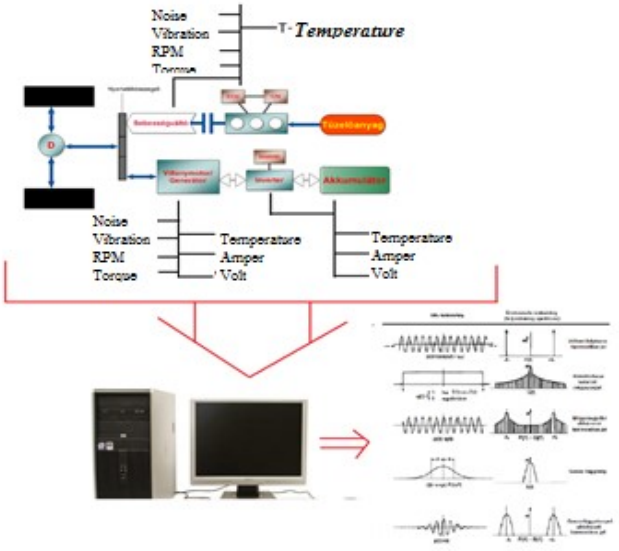


*Figure 1: Connect different sensors and diagnostic methods*

### *1.2 Non provable and repeatable methods for failure detection*

Since there is vehicle repair and maintenance the good mechanic could always listen to the noise of the car to be able to detect the fault. If they had a suggestion which parts can be the cause of the noise they listened to that part with stethoscope.

*Figure 2: Stethoscope in vehicle repair and maintenance*

## 2. MEASURING

### *2.1 Conditions*

To test our measuring system some test measurements were executed, and during it very highprofile and valuable experience was collected about this field of novel research.

The following test measuring scenarios were done during the research

1. standing vehicle
2. on the go
3. on the go, acceleration (0-50), deceleration (50-0)
4. let it slow itself down from 50 km/h to 0 km/h in ”D” transmission gear, rolling wheels and breaking in ”D” transmission gear (on the go)
5. keep the speed fixed 20 km/h
6. keep the speed fixed 35 km/h
7. listening to the radio
8. standing vehicle, turning the A/C on and off, using the OBD-II device also
9. take a longer trip with the vehicle, using the OBD-II device also (part I.)
10. take a longer trip with the vehicle, using the OBD-II device also (part II.)
11. test trip with the vehicle, the microphone is placed under the hood, using the OBD-II device also (part II.)
12. test trip with the vehicle, the microphone is placed under the hood, at the end of the trip turning the A/C on and off many times, using the OBD-II device also

To perform the measurements several state of the art tools and equipments were used. First of all a vehicle was basically needed to do the accomplish the research. Because the electric cars are the forward-looking ones, we used a ”VW E-Up!” electric car. Measurement devices were also needed for example an OBD-II device (to measure RPM and speed while recording the noise and compare them), accelerometer and not to mention the microphone as the most important part of our measurement system to detect faults in the vehicle analyzing the recorded sound.

### 2.2 Devices

To perform the measurements it was needed to choose measuring devices. Probably the state of the art automotive oscilloscope is the produced by Pico, and it is also available with useful components for example accelerometer with magnetic mounting assembly, high sensitivity microphone, signal cables and so on. Pico NVH Diagnostics Kit was also a good decision because of the huge user literature, helpful tutorial videos and remote warranty technical assistance.



*Figure 3.: Measure set up (OBD and Accelerometer)*

To be able to eliminate the wind noise some measurements were done with the microphone inside the passenger compartment but also some measurements were done in the engine bay.

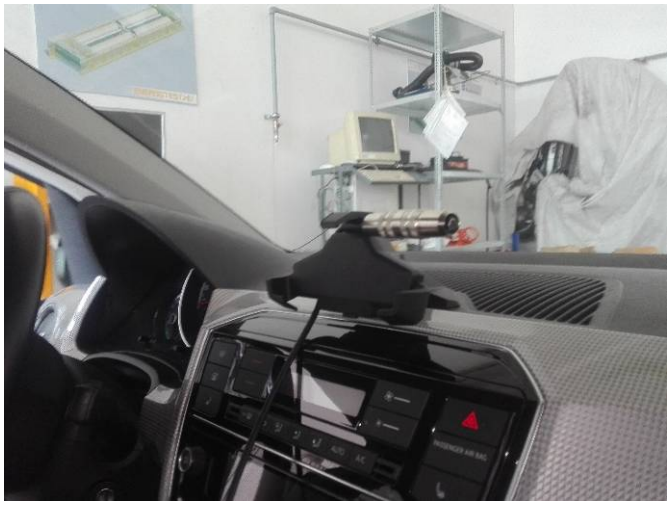

*Figure 4: Measure set up (microphone in the passenger compartment)*

## 3. RESULTS

### 3.1 On the go

During the journey, the microphone was placed in the passenger compartment during this measurement. At low speeds, the microphone did not detect significant wind noise, but due to insufficient noise insulation at higher speeds it did. In the case of roundabouts, significant sideways accelerations occurred, when the noise generated by the tires was very significant. Potholes on the pavement can be seen on the graph of the accelerometer. All these noises should be filtered to keep the sounds of the vehicle's electrical and mechanical components so that we can deduce from them to their technical condition.

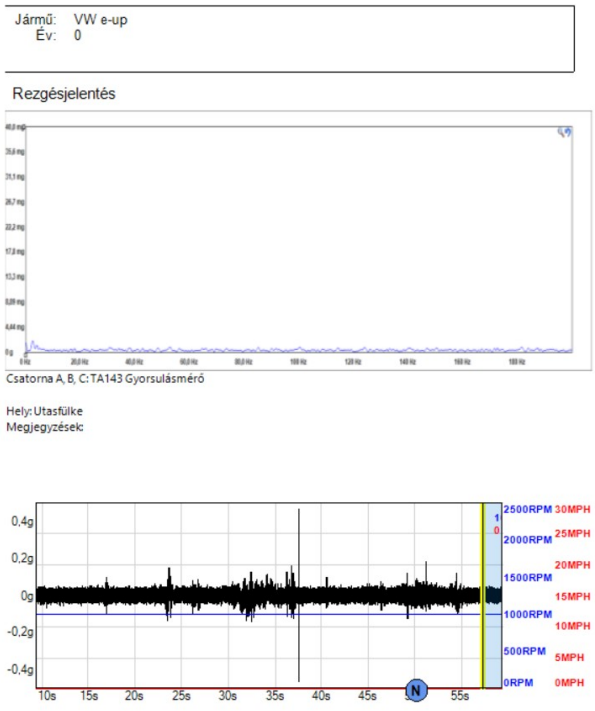


*Figure 5: Measure on the go*

### 3.2 Measurement #8 - standing vehicle, turning the A/C on and off, using the OBD-II

The large spikes shown on the graph indicate the operation of the A/C compressor.

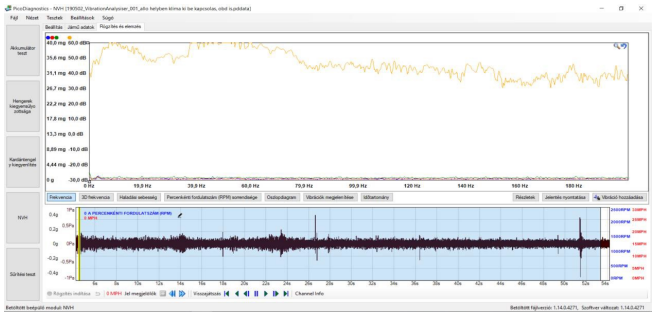

*Figure 6: Pikes indicates the A/C compressor*

### 3.3 Measurement #11 - test trip with the vehicle, the microphone is placed under the hood, using the OBD-II device also

Controlled by an idea, the microphone was moved from the passenger compartment to the engine compartment, helping to record the noise of the mechanical components much more and not noise of the passengers and the radio – because we do not need those. However, it turned out that wind noise is much more significant in this new case.

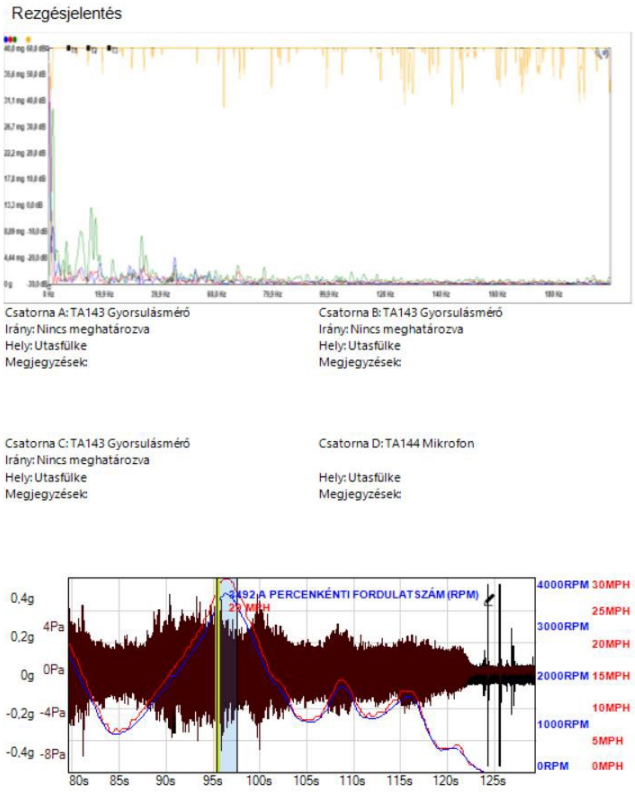


*Figure 7:* High wind noise during measurement

## 4. FURTHER RESEARCH OPPORTUNITIES

From the accumulated data and accidental future measurement results, a new method should be used to find out what correlations might exist between the specific faults of a particular vehicle and the audible noises from multiple microphones. To do this, it is necessary to filter out the noises, nonrelevant sounds, and be able to recognize the type of faults related to the specific vehicle type.
The above mentioned correlations could be performed using neural network system.
In this research, high-value, professional automotive measuring equipments were used. In production it would not be economically efficient using these expensive technologies so it would be necessary to use cheap microphones to measure the noises.
As a consequence the following future modifications will become necessary:

- use cheap microphones instead of professional measuring equipments
- find out the correlation between noises and faults
- filter out the noises
- do the above things for all types of vehicles
- continuously indicate to the driver the faults detected by the sounds

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