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Automatic conductive charging of electric cars

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Summary

Easy and convenient charging of electric cars is a desirable characteristic. Automatic cable-free conductive charging from road surface to cars is a potential possibility for simplifying the everyday life for users of electric cars, as well as increasing the efficiency of taxis and car pools. Charging infrastructure for electric cars could utilize the recent development for electric road systems (ERS) in which electrical energy is transferred during movement from the road infrastructure to the vehicle for both propulsion and charging of battery. However, continued development must be done before it is feasible to implement automatic conductive cable-free charging of cars.

Keywords: automated, car, charging, conductive charger, EV

1 Introduction

An electric road system (ERS) in which electrical energy is transferred during movement from the road to the vehicle for both propulsion and charging of battery, is a technology concept with great potential for reducing dependency on fossil fuels, reduced greenhouse gas emissions and increased energy efficiency in the transport sector [1]. There are ongoing studies and demonstration projects around the world in order to explore different techniques for energy transfer and different use cases [2].

Currently, there are three main concepts of road electrification: overhead lines, conductive rails, and wireless (mostly inductive) solutions. The technologies are being developed and marketed by different firms, and each one of the solutions has its own advantages and disadvantages. Ongoing and forthcoming demonstration projects will test ERS on public roads and in real-life environments, addressing various legal, political, economic, and efficiency aspects of ERS. Public road tests would provide decision makers and investors with a foundation for further investments that would bring ERS to commercial operation. The world's first demonstration of ERS for heavy vehicles started in June 2016 managed by the Swedish Transport Administration [3].

Charging infrastructure for electric cars utilizing ERS conductive rails would give a possibility for automatic cable-free charging, stationary as well as during movement, and thereby simplifying everyday life for users of electric cars.

RISE and Volvo Cars have conducted a study in order to evaluate the potential of using an ERS solution for automatic conductive energy transfer from road to electric cars that are stationary or moving slowly over short distances (e.g. queues). Examples of the two studied use cases are displayed in Fig. 1. Strengths, weaknesses and maturity readiness have been investigated for various solutions.

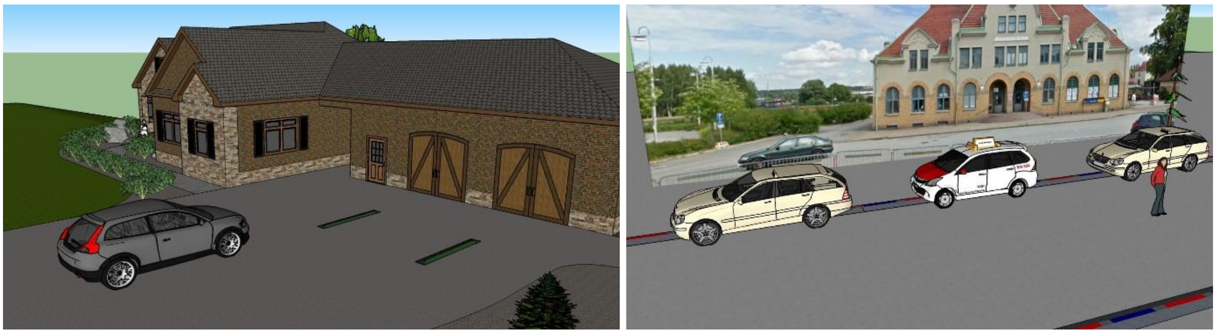

Figure1: In the picture on the left, a car is to be parked over a conductive rail that will transfer energy to the car while it is parked. In the picture to the right, taxi cars are charged while they are moving slowly along a conductive rail. These two pictures exemplify the two studied use cases for automatic conductive cable-free charging of cars.

2 Conditions

2.1 General requirements and expectations

From an automobile manufacturer point-of-view, automatic conductive charging of electric cars that are stationary or moving slowly needs to fulfil the following general requirements:

- Easy to use and approach (manual or automatic parking shall be possible)
- Safe to use both inside and outside the car (no electrical hazards)
- The vehicle shall be connected and communicate with electric vehicle infrastructure (payment if applicable, easy to find)
- Should work under all environmental conditions (snow, dirt, rain etc.)
- Should comply with all existing automotive and electrical standards
- Conditions to start/stop charging, e.g.
    - living objects detection in the case of stationary cars
    - detection of obstacles in charging lane in the case of moving cars

Automatic conductive cable-free energy transfer from road to a stationary car could replace today's normal cable-based convenience charging at 3,5 kW AC (usually during night time). It would be beneficial to achieve fast charging with as high power as possible (AC or DC). In comparison to inductive charging it is in our opinion expected that conductive energy transfer from road to a stationary car would enable higher charging power and generate less magnetic field emissions.

The use case of conductive energy transfer from road to cars that are moving slowly would imply an opportunity to charge in dedicated spots, e.g. taxi queues and car pool centrals, with as high power as possible (AC or DC).

A future detailed feasibility analysis is expected to result in several detailed requirements.

2.2 Functional safety

The functionality of solutions that could be used to enable automatic conductive charging from road to electric cars have been demonstrated in proof-of-concepts, on test tracks, as well as on public roads. However, it is of crucial importance for the automobile industry that the developers of these ERS solutions perform rigorous work on functional safety, i.e. ensures the freedom from unacceptable risk of physical injury, or of damage to property or the environment.

It is recommended that the developers make use of a methodology that involves a standardized systematic process, e.g. ISO 26262 for electrical and/or electronic systems in production automobiles or IEC 61508 that is applied for electricity distribution. Such process requires competence, systematic work and documentation. The steps of a principal process are outlined in Fig. 2.

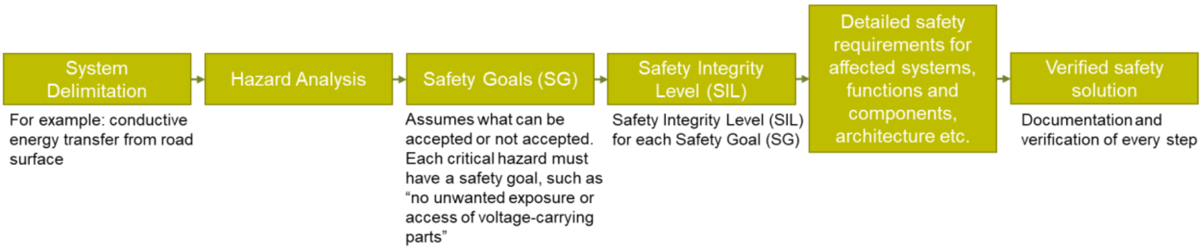

Figure2: The steps of a principal process to analyse and ensure functional safety of a system.

3 Technical options

A solution for conductive energy transfer from road to electric vehicles uses a conductive rail installed in the road to provide the needed energy. The energy is transferred to the vehicle via a robotic energy pick-up arm installed beneath the vehicle, and which follows the rail. As part of this study, four solutions have been considered to enable automatic charging of electric cars. The solutions are shown in Fig. 3.

3.1 Alstom ERS

Alstom has a service-proven power system for tramways called APS which supplies electricity through a third rail at ground level and eliminates the need for catenaries. The APS system has been used as basis when Alstom has developed its ERS system that involves two rails in the road surface level. AB Volvo has developed pick-up arms for heavy transport vehicles and tests have been made at a Volvo test site in Sweden. The vehicle integration is being performed as part of the Slide-in research project [4].

Alstom is a company with extensive experience and its ERS solution is based on a product that is used in many cities for energy transfer during movement. The main concern, in the case of cars that are stationary or moving slowly, is the need for electrical safety measures due to the exposed rails.

3.2 Alstom SRS

Alstom has also launched the SRS system intended for ground-based charging of standstill buses positioned over charging slots at bus stops. The electrical bus “Apis” from NTL that gets its energy via SRS is planned to be demonstrated in Paris during 2017.

The ongoing product development for the bus application is interesting, but an application for cars would probably need parking guidance as an additional feature.

3.3 Elonroad

Elonroad is a fairly new solution with a rail that consists of short segments in sequence. The rail is intended to be installed on the road surface and rises about 5 cm and have slantwise sides, the energy pick-up have at the least three contacts. A demonstration along a test track is being prepared in southern Sweden [5].

An easy installation process and a free energy pick-up design are advantages of Elonroad. The solution is intended to be used by both moving and stationary electric cars, but the development is still in a early phase.

3.4 Elways

The rail solution from the company Elways involves one rail with two trenches where the conductive parts are placed down in the trenches. The rail and a customized energy pick-up integrated into a medium sized truck are being prepared for a demonstration of electrified shuttle transports along a public road in the vicinity of the Arlanda Airport, Sweden, during 2017 [6].

The Elways solution has many years of development and successful tests in various environmental conditions. The solution is intended to be used by cars, but the recent development has been focused on the application for trucks.

Figure3: The four solutions considered for automatic charging from road to electric cars. Alstom ERS rails are displayed in the picture top left. An artist's idea of Alstom SRS is displayed in the picture top right. The lower left picture shows the Elonroad rail. The picture to the lower right shows the Elways rail.

4 Maturity and potential

The studied solutions have been developed over several years and the rail sub systems have gained maturity. Most of the recent development activities have been focused on heavy vehicles, even though cars have been considered by at least two developers. The energy pick-up arms adapted for cars are at the moment the least mature sub systems. The maturity of complete systems to be applied for cars are, at the time of writing, thus on the proof-of-concept level.

In spite of the present low maturity, conductive energy transfer from road to electric cars is interesting due to the possibility of the following use cases:

- Automatic fast charging with adjustable power for different vehicle types
- Automatic charging at public parking places (e.g. at super market)
- Automatic charging at private parking with no guidance and automatic driving
- Automatic charging at places where cars are frequently fetched (e.g. car pool)
- Automatic charging when driving in queues at a low speed (e.g. taxi)
- Automatic energy transfer (propulsion and charging) from road to different vehicle types with different power requirements at higher speeds

5 Conclusions and recommendations

It is an interesting future possibility for the automobile industry to use conductive energy transfer from road to electric cars that are stationary or moving slowly over short distances (e.g. queues). However, the studied solutions have today a low maturity in case of applications for cars, and continued development, especially of energy pick-up arms for cars, must be done before a conclusion of possibilities and potential can be made. Compliance to functional safety, user friendliness and easy availability are absolute requirements before a market introduction of a solution can be considered.

The following items are necessary to be managed by the solution developers in order to achieve a fruitful collaboration with the automobile industry, and before it is feasible to plan for implementations and demonstrations of conductive energy transfer from road surface to cars:

- Specification of appropriate application areas where conductive energy transfer from road surface with high power makes a difference (e.g. taxi queues, car pool centrals)
- ”Automotive-grade” energy pick-up with the right design
- Functional safety (especially electricity hazards)
- Standardization of public solutions initiated (or at least planned)

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