Wireless power supply implementation for electric vehicles batteries charging

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Alfredo Sonnante, Vision CEO
• Vision is a young consulting company specialized in design, management, promotion and distribution of industrial systems and innovative technology infrastructures.

• It proposes and provides technologies and innovative services for enterprises, public institutions and private users, through research programs with international partners and pilot actions.

• In the automotive research framework, Vision promotes the E-way® project, that is the result of a collaboration between Vision and the Italian Region of Puglia. The latter approved a measure of financial relief for the start-up of innovative micro-enterprises (Regional Regulation Nr. 25 of 11.21.2008).

• Vision mission is to innovate actual vehicles power chain, through power supply systems based on WPT (Wireless Power Transfer).
E-way® system consists of an electromagnetic carpet with emitters that can transfer power to a collector placed under the car floor in order to charge its batteries while the vehicle is moving.

2) Emitters carpet
3) Asphalt layer
5) Car collector
6) Car batteries
Eway®: physical aspects

A more complex model needs to be defined and more parameters can affect simulations and correspondent results.

A “dynamic” approach must be implemented in order to consider electromechanical interactions.

Virtual prototyping should be based on a transient to transient (Simplorer to Maxwell) analysis in order to evaluate all physical phenomena involved in this application.
Eway®: physical aspects

Current densities can be induced on the collector coil as a consequence of the following separated and independent effects:

**Motionless coupling**

Alternate source currents in the emitters generate a *time variant magnetic flux* that concatenates with the collector (even if the latter does not move).

**Motion coupling**

The relative motion between the emitter and the collector concatenates a *space variant magnetic flux* and generates the correspondent f.e.m.
Eway®: numerical approach

In order to take into account both the time and space variations (AC and motion), the numerical analysis should theoretically be carried out through a transient to transient with motion simulation (Simplorer+Maxwell with motion). However, in this case, the time stepping for the analysis should be fine enough to follow the much higher frequency periodicity of the alternate current.

A possible Simplorer scheme for a transient to transient with motion analysis.
Eway®: numerical approach

A typical vehicle cruise speed, that is the relative speed between the emitter and the collector carpet, is around 90km/h (25m/sec). This means that the induced current frequency is around $25\text{Hz}/d_e$ (where $d_e$ is the distance between two consecutive collector rows of the carpet).

If

- emitters and collectors have similar size
- emitters are adjacent in the carpet
- emitters’ alternate current are more than 100Hz

The frequency of the current induced by flux time variations and of the currents induced by flux space variations are quite different.

Physic phenomena are frequency decoupled and can be analyzed through different numerical approaches.
**Eway®: numerical approach**

**Motionless coupling**

A parametric, as a function of different position of the collector with respect to the carpet, transient analysis will be performed to evaluate the main stationary system performances.

**Motion coupling**

A velocity driven mechanical transient analysis will be performed to evaluate the main dynamic system performances.

*Transient (Simplorer) to transient without motion (Maxwell) system control.*

*Transient (Simplorer) to transient with motion (Maxwell) system control.*
Eway®: sample results

Sample of the induced currents on a collector that moves at 90km/h over an “one row carpet” of emitters placed at one meter distance each other. Current amplitudes increase as soon as they cross one of the emitters’ section.
Eway®: sample results

Sample of the induced currents on the collector that moves at 90km/h over an “one row carpet” of emitters placed at one meter distance each other. Current amplitudes increase as soon as they cross one of the emitters’ section.
Eway®: sample results

Sample of the induced forces on the collector that moves at 90km/h (toward the x direction of the coordinate system) over an “one row carpet” of emitters placed at one meter distance each other. Current amplitudes increase as soon as they cross one of the emitters’ section.

Forces along the x direction are mainly resistive and they oppose to the motion. The correspondent power is dissipated and cannot be collected.

Forces along the z direction do not generate mechanical work but they suggest that some energy can be collected toward batteries. This behavior reflects the alternator working principle, where the primary winding is represented by the planar carpet and the secondary winding is represented by the collector.