INGENIEURBÜRO DUSCHL

Prof. Dr.-Ing. Georg Duschl-Graw, Am Schloßpark 4, 15848 Tauche-Giesensdorf
Tel.: +49 (0)30 30612355, Mobil: +49 (0)171 1981346, Fax: +49 (0)30 30612356, E-Mail: Kontakt@Ingenieurbuero-Duschl.de Web: http://www.Ingenieurbuero-Duschl.de

October 2016

Inductive power transfer to mobile objects with three-phase tempel transformers

The initial situation: Increasing numbers of e-bikes, e-scooters and electric cars demand comfortable solutions for charge stations, especially in urban environments. Cable-based charging of electric cars needs manual activities of the drivers, which is impractical and might also cause electric shocks or provoke vandalism, especially in future years with increasing numbers of electric vehicles.

Inductive power transfer to mobile objects is therefore an elegant method and allows automatic charging processes without the need of cables and electric contacts. Most of the actual systems like from Mercedes [1] are using one primary coil and one secondary coil and can transfer up to 3.7 kW over a distance of 10…15 cm. Other systems like PRIMOVE from Bombardier are using lowerable coils with cross-sectional areas of several m² for e-buses and e-trucks to transfer up to 200 kW [2].

The problem: The main problems of inductive power transfer systems with large air gaps are the EMC (electromagnetic compatibility) and the very high leakage flux, which leads to very high currents in the coils, especially for higher power transfer. But coil wires diameters are limited and the European EMC emission limits are tight for higher frequencies. One solution to overcome the problem is to make the cross section of the coils bigger (PRIMOVE), which allows lower flux densities for the same power transfer. Another possibility is to increase the number of coils and to use e.g. a three-phase system with much lower losses than single-phase systems and with a constant power flow. Three-phase systems can't be realized with air coils which would produce a magnetic short-circuit.

A possible solution: The presented solution is a patented three-phase transformer with a small air gap and with minor magnetic leakage flux. The transformer is of the temple type and is built up symmetrical. The two parts of the transformer are normally touching each other during operation. This system can be used as "Inductive Power Plug (IPP) in a power range of 100 W – 20 kW or more. For low power systems up to several 100 W the secondary part of the transformer can directly include the charge controller and the whole system might be plugged manually in an IPP (see figures 2, 3), which at the same time locks the movable object to the charge station. For electric cars the secondary part of the transformer has a diameter of ca. 30 cm and a height of ca. 10 cm for an output power of 10-15 kW. This part is fixed at the vehicle's floor and can be lowered automatically onto the underfloor installed primary part. The primary part might also be lifted automatically or a charge robot which crawls automatically under the car (charge crawler) carries the primary part or a mechanical arm, which can be swiveled, holds the primary part. Actual efficiency of the transformer system is up to 92 %, it works noiseless with electrical frequencies of ca. 20 kHz (>50 kHz possible). Power range is of 10 – 15 kW and with enforced cooling up to 50 kW or more. The primary and the secondary part of the transformer must be positioned with an accuracy of some mm. Enlarging the cross-sections of the pole shoes will allow misalignments of 1-3 cm. Almost complete elimination of the flux density outside of the transformer might be achieved by using aluminum pots as shields around the transformer parts. However it is also possible to leave an air gap of several cm between the primary part of the transformer and the secondary part. In this case the diameters of the coil wires must be made bigger and also the capacitors for the compensation.

INGENIEURBÜRO DUSCHL

Prof. Dr.-Ing. Georg Duschl-Graw, Am Schloßpark 4, 15848 Tauche-Giesensdorf
Tel.: +49 (0)30 30612355, Mobil: +49 (0)171 1981346, Fax: +49 (0)30 30612356, E-Mail: Kontakt@Ingenieurbuero-Duschl.de Web: http://www.Ingenieurbuero-Duschl.de

October 2016

Possible applications: Applications for the invention are the e-mobility sector including e-bikes and delivery trucks, inductive power transfer in public environments, where conventional power plugs cause problems due to the high voltage and corrosion, IPP in explosion prone areas, IPP under water or IPP for ships' power supply.

Similar systems proposed by other authors: *1.)* Magnetic modeling of a high-power three phase bi-directional IPT system, D. J. Thrimawithana, U. K. Madawala, A. Francis, M. Neath, The University of Auckland, IECON 2011 - 37th Annual Conference on IEEE Industrial Electronics Society, November 2011. 2.) FEM analysis of couplers for inductive power transfer, A. Fuchs, H.-P. Schmidt, Technical University of applied Sciences Amberg-Weiden, ISSN 0033-2097, 2014

[1] https://www.mercedes-benz.com/en/mercedes-benz/next/e-mobility/electric-cars-without-charging-plug/

[2] http://primove.bombardier.com/en/applications/e-bus.html

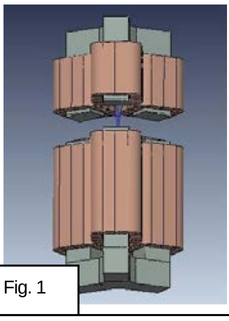

Fig. 1

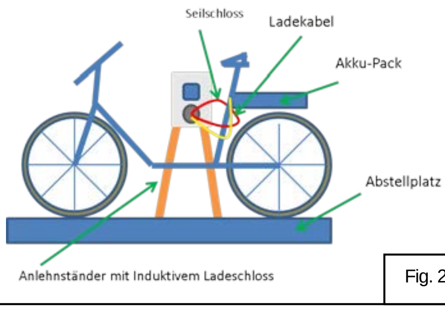

Fig. 2

Fig. 3

Fig. 4

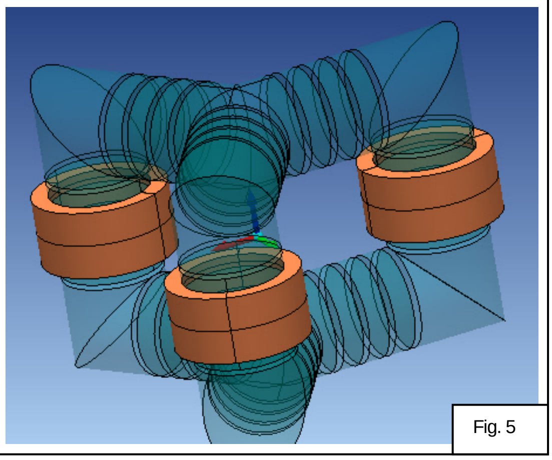

Fig. 5

Fig. 6

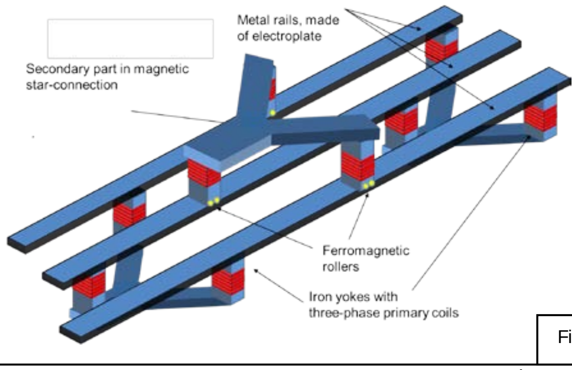

Fig. 7