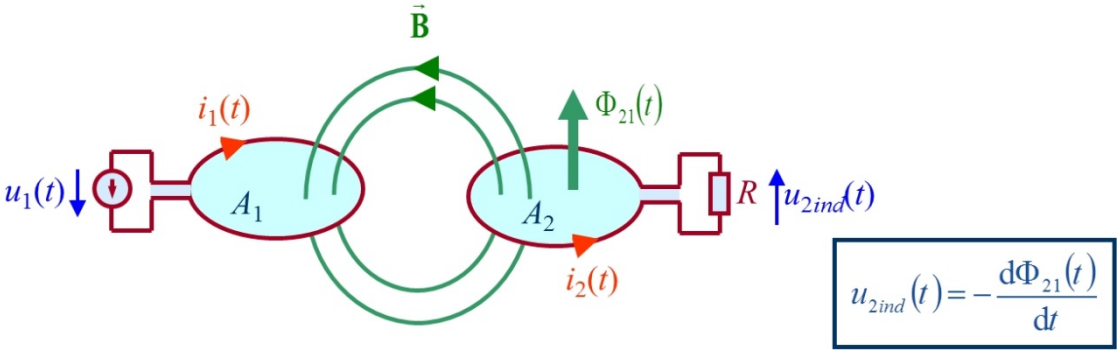
Inductive charging with data transmission

Author: ***Armin Wegener***

Electromagnetic induction (also known as Faraday's law of induction, named after Michael Faraday, short: induction) is the production of an electromotive force across a conductor when it is exposed to a varying magnetic field.



Scheme of magnetic induction

Wireless energy transfer (also known as separate energy transmission, wireless power transmission or contactless power transfer) means energy is transferred from one object to another. This may involve various forms of energy, for example kinetic or electrical energy. In general it refers to an electrical structure, whose required power is not fed by cables and electrical contacts, but by electromagnetic fields or other physical mechanisms. The benefits include increased mobility, as well as the absence of electrical contacts and thereby related problems. All of this results in a water and dust-proof design of the components. Even gas-tight applications are feasible. This allows for an ATEX approval and use of applications in hazardous areas. Due to the dust-proof design of the inductive charging, such solutions are predestined for the use in many different areas. Renowned manufacturers of machine tools already rely on these solutions worldwide.

Inductive energy transmission is the most widespread method. Wireless energy transmission is often used synonymously for inductive energy transfer. As far as electrical charging is concerned, a distinction is made between a stationary primary component and a secondary component. These are mobile applications for mobile phones, electric toothbrushes, hedge trimmers, infusion pumps or mobile gas detectors.

Energy efficiency requirements and their consequences

Regulations such as CEC*, ErP* or DOE* are normative points. These energy-saving standards had and still have a strong influence on charging technology in general and of course on the development of inductive chargers. Unlike before, when chargers used to consume energy during the entire operating time, state-of-the-art chargers can identify if a secondary component (rechargeable battery) is inserted, and monitor its charging status. This allows for a much more energy-efficient operation.

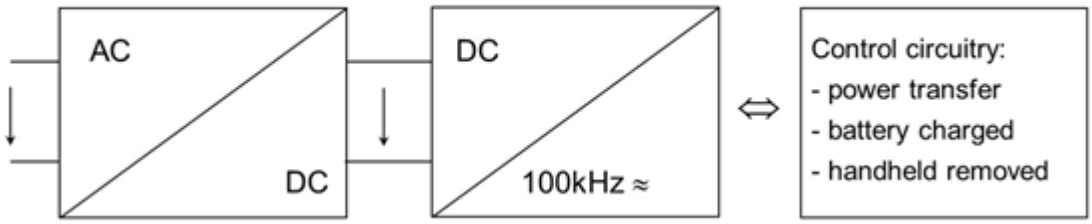
Q I standard versus fixed position

The QI standard, introduced in 2008 is meant to facilitate the charging of various secondary applications. For this purpose, diverse manufacturers of chargers and electronic products formed an alliance. The standard enables the charging of different secondary components by using a user-defined sized primary component (for example a plate). Its only drawback is the relatively high energy consumption, as the primary unit contains a significant number of charging coils whose efficiency is crucial for transmission losses.

In the fixed position the primary and secondary components are complementary. Although the charging is then restricted to specific applications, a more cost-effective production and energy-efficient operation is achieved by using a firmly optimized coupling of the charging coils.

Technical optimization by two-stage approach:

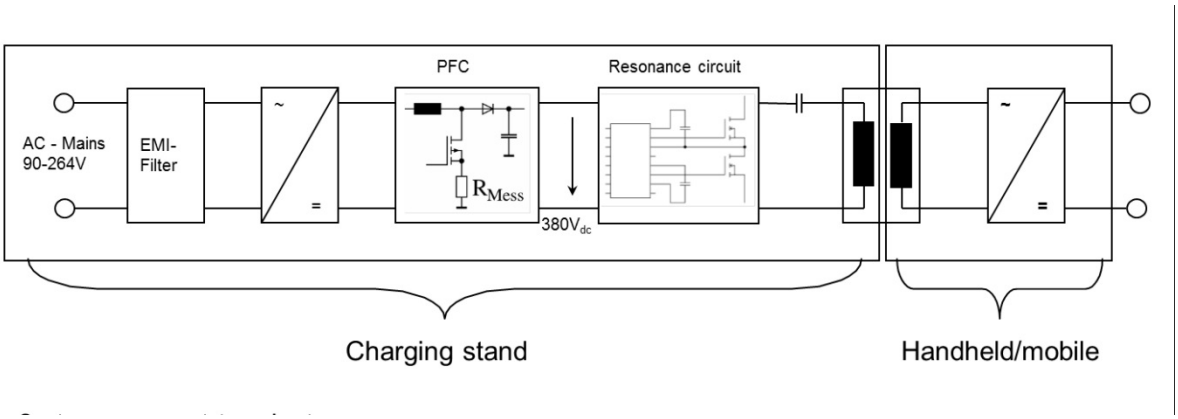
The two-stage approach is relatively new. In the first stage, the worldwide differing mains voltage (Japan 100 V (+/-10%) to EU (240 V (+/-10%)) of 90 V – 264 V is automatically identified and controlled. Thus the device can be used worldwide, as only the primary plug needs to be changed.



Scheme: Optionally a D C source of 4 – 32 V can be used, depending on the transmitted power.

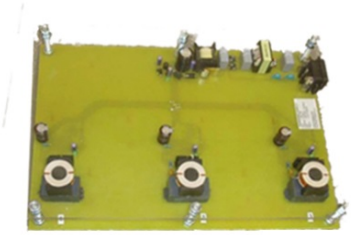
The second stage (also known as resonance level) contains a power transformation. A wide power range of 0.1 to 100 Watts and therefore charging of various secondary applications is possible. The advantage of this approach is evident:

- favourable Engineering costs
- favourable manufacturing costs
- sales benefits due to charging of different applications
- optimization for different mains voltages and load changes



2-stage approach: PFC as 1st stage, offers sinusoidal input current in accordance with EN61000-3-2
Low power in the resonant circuit and zero-voltage-switching allow higher efficiencies
Efficiency ranges from 80% (@ 100Vac & Vout = 15V) until 85% (@ 230 Vac & 24V) for a gap of 5mm between the inductors
Reduced gap => higher coupling factor => increased efficiency

This allows, for example, the charging of various applications in a primary component of the same manufacturer. The power input of the secondary component is unimportant. Another significant advantage of this approach is the detection of the battery status. When the battery is fully charged, the primary component can, depending on the settings, change to trickle charge or turn off the charging process. In addition, the charger recognizes whether a secondary component is inserted or not. This results in low standby losses and extreme energy restriction respectively, in regards to the terms of enhanced standards such as DOE* or TIER2017* (proposed by the EU).



Example: Inductive or contactless charging respectively for up to 3 appliances

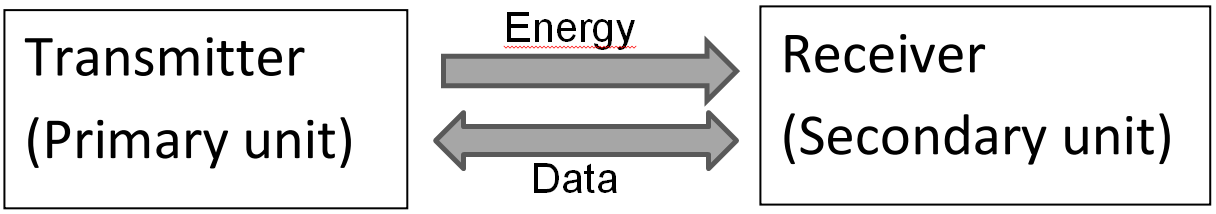
„Pick Up Core“ for a secondary unit.

To summarize the following can be stated, in contrast to the QI standard, the two-stage approach not only render benefits in the energy efficiency sector, but also reduces production costs for the manufacturer, and is also user-friendly for the customer. The global trend is strongly tending towards the two-stage approach, and it can be assumed that a new industry standard is about to be instituted.

Inductive data transmission

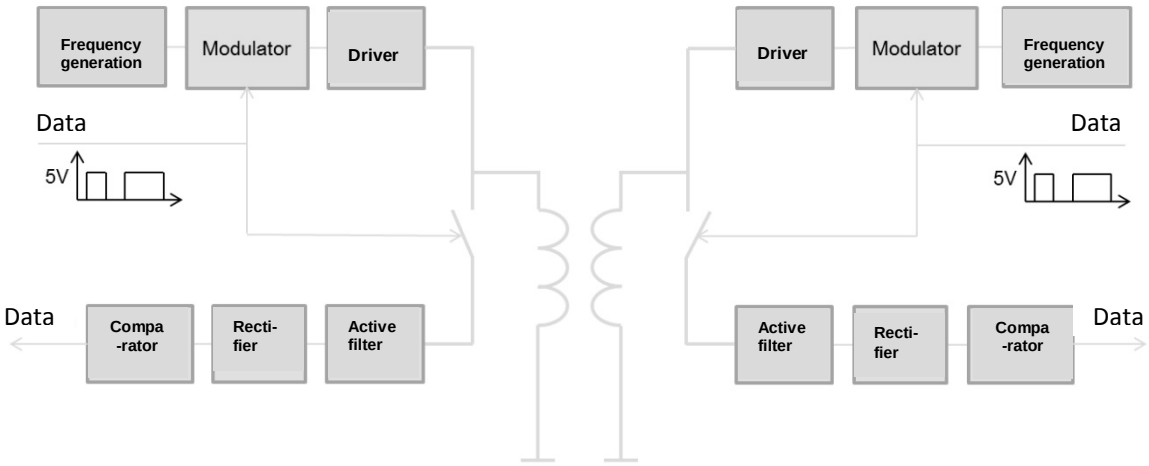
Inductive data transmission allows message signals to be transmitted in both directions with the assistance of the electromagnetic induction. Any required energy can also be transmitted from the stationary unit to the primary unit simultaneously and contactless.

Frequently, not only a contactless energy transfer isolated from the application is required, but also a data transfer, in order to fully utilize the advantages of the closed housings.



Scheme : Energy transfer from primary unit (transmitter) towards secondary unit (receiver). Data transfer in both directions with up to 500 kbit/sec

In the simplest case, the signal transfer from the primary unit to the secondary unit is triggered by turning a high frequency magnetic field on and off, which corresponds to an amplitude modulation. The electric voltage generated within each of the receiver coils is rectified by a diode. The signal is thereby transmitted in both directions.



Scheme: Outline of RxTx unit's asymmetric structure

In this case the benefits of the inductive charge also apply. Dust, water and gas-proof allow the use in hazardous and hostile environments. Data transfer rates of up to 500 kilobits/sec are possible.

The data exchange between primary and secondary component offers many opportunities. Not only does it identify the type of battery used in the mobile application and adjust the charging status, but it also adjusts the charging current automatically, so that the charger can optimally charge a variety of batteries (eg. LiO, NiMH, etc.) with different cell packs.

A quick and reliable identification of mobile applications and firmware updates are also provided. Therefore a primary component can both identify different secondary applications and charge them as specified.

Footnote:
*CEC=California Energy Commission, energy standard of the California Energy Commission for chargers
*ErP=Energy-related Products, eco-design directive 2009/125/EG, 1275/2008 for standby losses: currently <500
*DOE=Department of Energy, a standard of the U.S. Department of Energy for energy efficiency improvement, effective February 2016
*TIER2017= EU standard for energy reduction, effective 2017

Dipl. Ing. Armin Wegener

studied electrical engineering at the RWTH Aachen. Following his studies his career steps encompassed the Philips Forschungslabor Aachen and Briarcliff Manor (NY), robbe GmbH Industrietechnik and Ascom Frako. In 1995 he started with FRIWO as head of predevelopment. Since 2002 he has been managing the R&D department in Ostbevern (Germany) and Shenzhen (China).