

# <u>WIRELESS POWER TRANSFER –</u> <u>USEABLE IN ROBOTS ?</u>

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WURTH ELEKTRONIK MORE THAN YOU EXPECT



- World of Robots
- Wireless Power Transfer (WPT) Technology
- WPT in AMR/AGV





#### **MARKET BRANCHES**

Trade (Amazon, Alibaba,..)



Industry



#### Logistics (DHL, UPS,..)



Automotive



Medical



Agriculture





#### WHAT ARE WE TALKING ABOUT ?

#### AMR (Autonomous Mobile Robots)



#### AGV (Automated Guided Vehicles)



Forklift





#### Global Mobile Robot Manufacturers 2022



Source: AGV network website



#### **Global Mobile Robot Market**

#### Material Transport Mobile Robot Market



### Global Automated Guided Vehicle Market

OPPORTUNITIES AND FORECAST, 2020-2027

Global Automated Guided Vehicle Market is expected to reach **\$13.52 Billion** by 2027.

Growing at a CAGR of 16.6% (2020-2027)



Source: https://www.alliedmarketresearch.com/automated-guided-vehicle-market



#### WHAT IS THE MOTIVATION BEHIND CHANGING TO AMR/AGV?

- Severe lack of availability of skilled personnel
- Start with automation of simple tasks in the work flow (e.g.20% of global pallet movements can be done by AMR)
- Implementation cost will be compensated fast due to possible 24/7 usage and reduced personnel cost
- Reduced vulnerability of operations (e.g. war, pandemic (staff sick or quarantined))



# FORKLIFT FATALITIES BY TYPE OF ACCIDENT:

Fatal Accident Type	%
Crushed by vehicle tipping over	42
Crushed between vehicle and a surface	25
Crushed between two vehicles	11
Struck or run over by a forklift	10
Struck by falling material	8

Source Safety in Numbers and OHCSA report, the US industry in 2018



# Now, why Wireless Charging?





#### TREND SURVEY ON LINKEDIN 2021

Next 5 years. What Trends will become standard in the AGV/AMR Industry?

Inductive Wireless Charging	42 %
Cloud robot management system	23 %
Natural Nav replaces Laser Nav	32 %
Other (indicate in comments) 1	4 %









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#### **INTRODUCTION TO WIRELESS POWER TRANSFER**



#### Inductively coupled magnetic resonant system

- Frequency: kHz regime
- Distance: short range regime



[1] R. Bosshard, PhD thesis 2015, "Multi-Objective Optimization of Inductive Power Transfer Systems for EV Charging"

### FIGURE OF MERIT FOR EFFICIENT POWER TRANSFER





#### **3D FEMM ANALYSIS OF WPT MODEL-ANGULAR MISALIGNMENT**



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The coupling factor drops already below0,4 at a distance of half of the coil radius!



### Coupling versus coil displacement





#### AC Loss Behaviour of Wireless Power Transfer Coils



- AC behavior of each coil is determined by interplay of wire type, winding geometry, number of layers and density of turns
- Litzwire coils outperform their solid wire counterparts
- Solid wire coils with high density of turns show strongest derating



#### Improvement using ferromagnetic shielding



With shielding







#### <u>Magnetic field simulation full ferrite</u>





#### Magnetic field simulation with center hole





 $r_{\rm in} = 5 \text{ cm}$  $r_{
m out} = 10 \text{ cm}$  $n_{
m turns} = 10$ 

 $L = 32.3 \,\mu\text{H}$  $I_{\text{peak}} = 10 \,\text{A}$ 



#### Magnetic field simulation with 6 stripe ferrite shielding





 $r_{\rm in} = 5 \text{ cm}$  $r_{
m out} = 10 \text{ cm}$  $n_{
m turns} = 10$ 

$$L = 25.6 \,\mu\text{H}$$
  
 $I_{\text{peak}} = 10 \,\text{A}$ 



#### **TECHNICAL PARAMETERS (COIL RELATED)**

All parameters can be tailored e.g. to the application or regional approval

 Power
 100 W to 16 kW
 typical 3 kW

 Efficiency
 >90%

 Voltage
 15 – 60 V

 Current
 40 – 70 A

 Frequency
 80 – 150 kHz

 z – Distance
 5 – 250 mm
 typical 40 mm



#### **WIRELESS POWER CHARGING OPTIMIZATION**







Source: Varta Website

Coils – Electronics – Battery have to match to reach the best result for the application





# Wireless energy systems

5) Stationary Stationary charging 1 Wallbox pad Mobile Unit and 3 Battery system mobile charging pad Energy management 5 etaHUB 3 2 Wiferion

#### WIRELESS CHARGING CONCEPTS

#### Charging & Service Area



Source: emeia.sumitomodrive.com

Charging strip during work



Source: Magment website

#### Process Integrated Charging Spots



Source: Wiferion



## LACK OF STANDARDS

Currently no standard

Activities ongoing/starting in the Wireless Power Consortium WPC

Areas which use AMR/AGV's are currently mostly closed, optimized systems. Therefore the need of a standard/interoperability is maybe not top priority.

EV's have a standard/approval as here interoperability is a topic (like in mobile phones) SAE J2954

Nevertheless:

All solutions have to fullfil regulatory requirements e.g. C E , EN55011, SAE, FCC, RED



#### **ADVANTAGES OF A WIRELESS POWER SOLUTION**

- Completely sealed e.g. IP 68 resistance
- Precise positioning at charging spot (automated solutions)
- Omnidirectional positioning
- Applicable to all vehicles used in the process
- No metal contacts No sparks
- Maintenance free no cleaning or contact replacement needed





