Contactless Connectivity

Dirk-Jan “DJ” Riezebos

TE Connectivity – Industrial Solutions
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• What is Contactless Connectivity?
• What are the benefits and applications?
• What are the technology options considered?
• What has been implemented and how does it work?
• Next generation requirements for RF link

• Q&A and Demonstration
TE Connectivity
Introduction
IN A WORLD WHERE EVERYTHING IS CONNECTED, EVERY CONNECTION COUNTS
Invested in Engineering, Invested in Your Success.

$13+B ANNUAL REVENUE

5% OF SALES PER YEAR INVESTED IN R&D

20,000+ PATENTS ISSUED OR PENDING

8,000+ ENGINEERS

95,000+ EMPLOYEES

13 GLOBAL DESIGN CENTERS
Global Scale, Local Strength

AMERICAS
- 32% of salespeople
- 1,900 salespeople
- 9 design centers
- 35 manufacturing sites

ASIA (excluding China)
- 18% of salespeople
- 1,300 salespeople
- 3 design centers
- 14 manufacturing sites

CHINA
- 15% of salespeople
- 525 salespeople
- 1 design center
- 17 manufacturing sites

EMEA
- 35% of salespeople
- 1,900 salespeople
- 6 design centers
- 31 manufacturing sites
Well Positioned in Industries That Are Growing

- **Transportation Solutions**: $4.8B
- **Consumer Solutions**: $2.0B
- **Industrial Solutions**: $3.1B
- **Network Solutions**: $3.6B
Broadest Range of Connectivity Solutions

- CONNECTORS
- FIBER OPTICS
- PRECISION WIRES & CABLES
- ANTENNAS
- SEALING & PROTECTING
- CIRCUIT PROTECTION

500,000 PRODUCTS
Connectivity for any Application

- Automobiles
- Factory
- Aircraft
- Hospital
- Heavy Industry
- Office
- Power Plant
- Robotics
- Computing
- Mobility
- Environmental
- Railway
Contactless Connectivity
Introduction
Contactless Connectivity: what is it?

A hybrid interconnection system, based on both contactless power and contactless data technology, which can easily mate (and un-mate) over a short distance (so without using mechanical contacts)
Key Customer Requirements & Benefits

• Improved reliability:
  – Contactless connectivity delivers robust power & data
    without wires or physical contact; hermetically sealed

• Greater flexibility:
  – Unlimited range of motion, vibration, tilt, misalignment, rotation and through materials (eg through walls of tanks).

• Improved safety:
  – No arcing; ideal in hazardous environments

• Cost savings:
  – No wear and tear improves up-time and reduces maintenance
Contactless Connectivity – Industrial Driving TCO Reduction & New Applications

- Contactless but acts like normal connector
- Freedom of movement in x/y/z, rotation & tilt
- Unlimited mating cycles & vibration resistant
- Mating in harsh environment e.g. water, dust
- Spark-free for explosive environment

Centrifuge
- CCP benefit:
  ✓ Rotation
  ✓ Through walls
  ✓ Hermetically sealed
- Customer benefit:
  ✓ More machine uptime
  ✓ More production flexibility

Printing
- CCP benefit:
  ✓ Freedom of movement in x/y/z
  ✓ Rotational freedom
  ✓ 4 analog or 8 discrete channels
- Customer benefit:
  ✓ More productivity, higher yield
  ✓ Less set-up time

Carriers
- CCP benefit:
  ✓ On-the-fly testing
  ✓ 4 analog or 8 discrete channels
  ✓ Small form factor
- Customer benefit:
  ✓ Smarter carrier systems

Robotic
- CCP benefit:
  ✓ Freedom of movement in x/y/z
  ✓ Rotation and tilt
  ✓ Unlimited mating cycles
- Customer benefit:
  ✓ More productive robots / grippers
  ✓ More uptime

Milling
- CCP benefit:
  ✓ High speed rotation
  ✓ Resistance against lubricants
  ✓ Maintenance free
- Customer benefit:
  ✓ Process transparency
  ✓ More reliable & safer chucks

Molding
- CCP benefit:
  ✓ Endless mating cycles
  ✓ Resistance vs harsh environment
  ✓ Smart on-the-fly couplers
- Customer benefit:
  ✓ Higher yield / thru-put
  ✓ Saving in maintenance cost

Rotating Tables
- CCP benefit:
  ✓ Rotational freedom
  ✓ 4 analog or 8 discrete channels
  ✓ Small form factor
- Customer benefit:
  ✓ Parallel processing
  ✓ Smarter production
Application example – Robotic

Ariso benefits:
✓ Freedom of movement in x/y/z
✓ Rotation and tilt
✓ Unlimited mating cycles
✓ No need to clean connectors
✓ Robot can pick its own tool automatically

Customer value:
✓ More productive robots
✓ More uptime
## Contactless Connectivity - Technology Options

<table>
<thead>
<tr>
<th><strong>Data Link</strong></th>
<th><strong>Pro</strong></th>
<th><strong>Challenges</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacitive coupling</td>
<td>Low EMI. Also suitable for ring structures.</td>
<td>Requires significant plate area, challenging for tiny rotating couplers</td>
</tr>
<tr>
<td><strong>RF, 60 GHz</strong> (OOK, ASK, QAM)</td>
<td>Large bandwidth (&gt;1 Gbps), low latency (nanoseconds)</td>
<td>Should generate a circular polarized wave to support rotation</td>
</tr>
<tr>
<td><strong>RF, 2.4/5 GHz</strong> (e.g. GFSK, MSK, ASK)</td>
<td>Easy near field antenna design (simple loop), RF solutions widely available. Up to 2 Mbps.</td>
<td>No high bandwidth without OFDM, but that increases latency.</td>
</tr>
<tr>
<td><strong>RF, sub GHz</strong> (e.g. FSK)</td>
<td>Easy near field antenna design (simple loop), RF solutions widely available</td>
<td>Low bandwidth (sub Mbps)</td>
</tr>
<tr>
<td>Via ICPT power link</td>
<td>No separate antenna needed</td>
<td>Low bandwidth (10-100kbps)</td>
</tr>
<tr>
<td>Optical</td>
<td>Very high bandwidth possible (&gt; 10Gbps)</td>
<td>Sensitive to dust and dirt, precision optics &amp; lenses needed</td>
</tr>
</tbody>
</table>

| **Power Link** | | |
|----------------|----------------|
| **Inductively coupled power transfer (ICPT)** | High power density / reasonable distance / high efficiency possible, technology available | Can not penetrate metal |
| **Capacitive Power Transfer (CPT)** | Can penetrate (floating) metal, low EMI | Low power density, short range |
| **Ultrasound / vibration** | Can penetrate well through matter (hulls) | Research phase, depends on medium. Low power levels still. |
Contactless connectivity

Transparency – “Act like a normal connector”

PHY = Host/device physical layer

- = signal (data transport)

- - = power
Contactless connectivity
Transparency – “Act like a normal connector”

Host

PHY

PTx coupler

PHY

Contactless i/f

PHY

PRx coupler

PHY

Device

PHY

Contactless physical layer

Host/device physical layer

signal (data transport)

power

PHY

PHY

PHY

PHY

PHY

PHY

PHY
Ariso LP1 platform implementation

**DC/AC Converter with RPP**
- 2.4 GHz transceiver
- Near Field antenna
- Power Coil
- LC resonance
- ICPT
- Dynamic tuning

**AC/DC Converter with OLP**
- 2.4 GHz transceiver
- Near Field antenna
- Power Coil
- LC resonance

Data
- 4 analog or 8 digital I/O

Power
- 24V DC
- GND1

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What did we implement? Ariso LP1 platform
best in class contactless coupler solution for sensor applications

- M12 diameter for 6 Watt output power
- Highest power density: ~0.5 Watt/cm³
- Best in class Power-over-Distance: 1/3 of the diameter = up to 4 mm Z-distance for M12
- Dynamic tuning: high efficiency over variable loads and distances
- Reliable data link: uses redundancy in 2.4 GHz transmission & minimized far field interference
- Safety: reverse polarity (RPP), overload (OLP), over-temp (OTP) and foreign object protection (FOP)
- EMC & safety compliant (CE)

Diagram:
- DC/AC Converter with RPP
- AC/DC Converter with OLP
- 2.4 GHz transceiver
- ICPT
- Power Coil
- LC resonance
- Near Field antenna
- 4 analog or 8 digital I/O
- Dynamic tuning
- FOP
- OTP
- GND1
- GND2
- Power 24V DC
- Data
- 24V DC up to 6 W
Technology Behind the Scenes

Inductive Power Transfer

- Resonance principle
- With dynamic tuning to cope with variable loads and distance Z
- Frequency in the range of 150k-300kHz

• Max. z-distance is about 1/3 of the diameter D: M12 gives ~4 mm Z-distance.
Power link design overview

Vin 24VDC → Reverse Polarity Protection → DC-DC Conv. (Buck) → DC-AC Converter with DT → Primary Resonant Tank

Power Transmitter PTx

Power Receiver PRx

Rectifier → DC-DC Conv. (Buck-Boost) → Vout 24VDC

Vout

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2.4 GHz loop antenna design fitting M12

Near Field operation: \( \pi \times D < \sim \lambda/10 \)
Good magnetic coupling: \( D > \sim \text{max. distance} \)

\[ \Rightarrow D = \sim 4 \text{ mm when } \lambda = 124 \text{ mm (2.4 GHz)} \]

\[ \Rightarrow \text{Fits the M12 design} \]
2.4 GHz Loop antenna & matching circuit performance

![Graph showing S-parameters vs. Frequency for different distances and loss types.]

- **Return loss 0mm distance [mm]**
- **Insertion loss 0mm distance [mm]**
- **Return loss 5mm distance [mm]**
- **Insertion loss 5mm distance [mm]**

Frequency [GHz] vs. S-parameters [dB]
Next generation Target System specification

Data link

- Peer-2-Peer → no sharing of media like WiFi
- Short range → up to 20 mm
- Dynamic pairing
- Transparent
- RF link to be able to support multiple types of wired interfaces
- Small form factor → preferably smaller than 4 x 4 mm
Next generation Target System specification

Data link

• Low power consumption $\rightarrow$ preferably less than 100 mW
• Low latency $\rightarrow$ $\leq$ 1 $\mu$s
• Circular Symmetry: antenna should allow for rotation
• High Speed $\rightarrow$ $\geq$ 5 Gbps bit rate on wired interface
• Robust to misalignment, rotation, tilt, …
• Robust to different media between the Tx and Rx
• …
Conclusions

• TE created the smallest form factor (M12) solution for contactless couplers with the highest power density (~0.5 W/cm³). Evaluation kit available

• A multi-disciplinary TE team, with expertise in magnetics, RF, mechanical, thermal and circuit design & simulation has been established for creating (customized) contactless connectivity solutions.

Next steps

• Research & development of high speed (industrial) communication standards using new RF link solutions

• Exploring and enabling new applications
Live demonstration of Ariso LP1
Ariso Websites

- Ariso general website: www.arisocontactlessconnectivity.com
- Evaluation kit, digital version: www.te.com/catalog/pn/en/2229389-1
EVERY CONNECTION COUNTS