

DIGITAL WE DAYS 2024



DESIGN FOR MANUFACTURING (DFM)

Aldo De Michiel

WÜRTH ELEKTRONIK MORE THAN YOU EXPECT

WHAT IS DESIGN FOR MANUFACTURABILITY?

- Plays a critical part in the whole lifecycle of the component.
- From the early stage of the development.
- Affects cost, quality, and reliability.

**I am
Optimus
Design!**

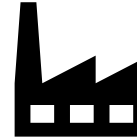


Credits: Hasbro

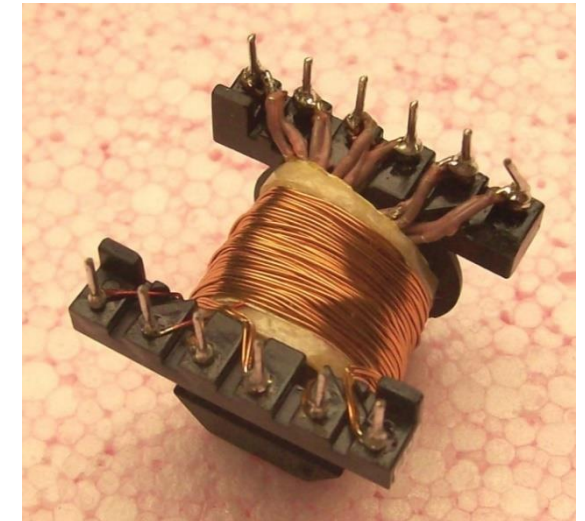
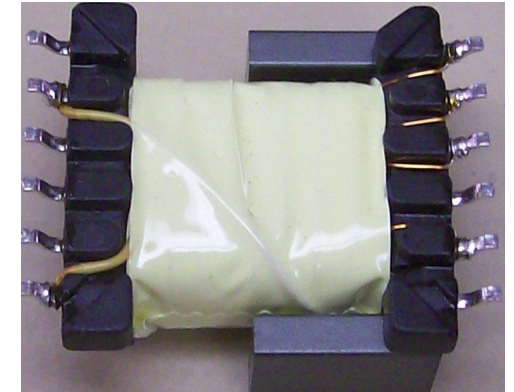
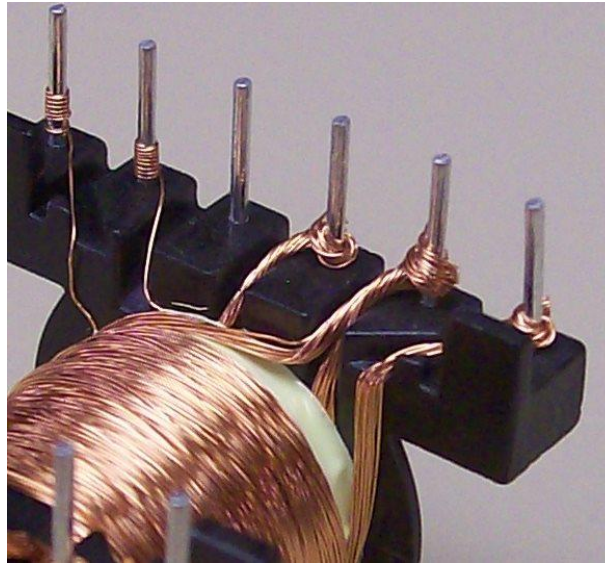
It is not desirable to have a power transformer with the best performances, but unreliable, unproducible, and expensive.

WHY DO WE DO DESIGN FOR MANUFACTURABILITY?

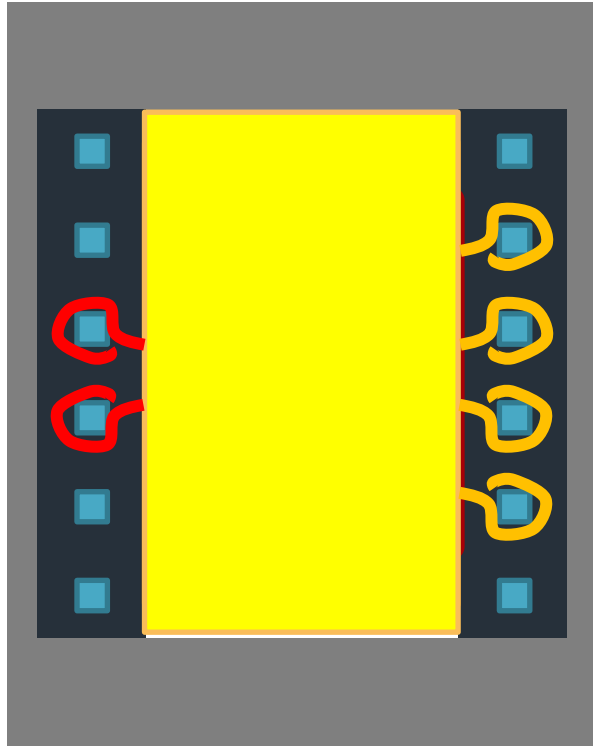
- To increase reliability
 - Design adapted to proven and repeatable processes.
- To reduce cost
 - Automated processes where possible.
 - Reduced scrap.
- To reduce lead time of the finished good
 - Use standard and available components.
 - Reduce rework and iterations.



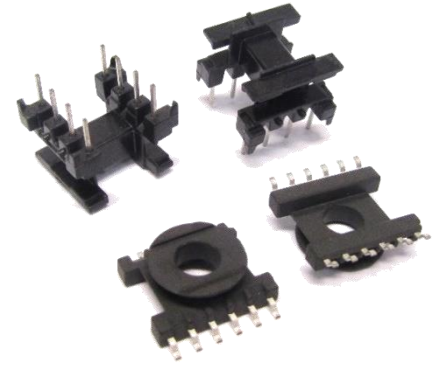
WHAT WE WANT TO AVOID



WHAT WE NEED TO BUILD UP A TRANSFORMER



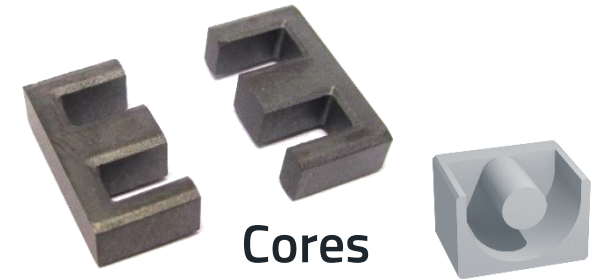
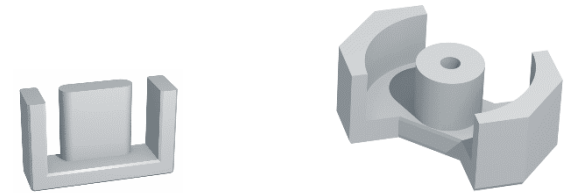
Tapes



Bobbin



Wires



Cores

Other Components

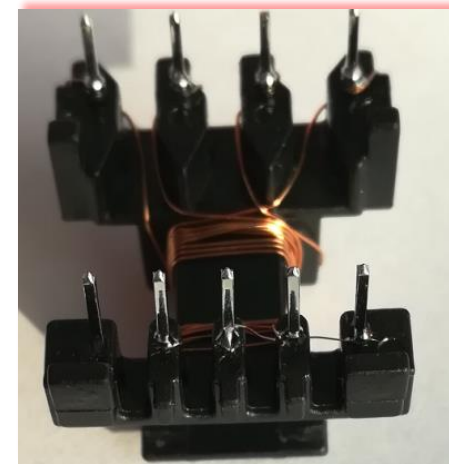
Clip

Adhesive

Varnish

RAW MATERIAL - BOBBIN

- Thermoplastic (PBT, PET, LCP)
 - ▲ Easy to mold
 - ▲ Flexible
 - ▼ Low melting point
 - ▼ Easily deformed
- Thermoset (PM9630, WH9100)
 - ▲ High Temperature (soldering)
 - ▲ Robust
 - ▼ Less flexible
 - ▼ Difficult to mold



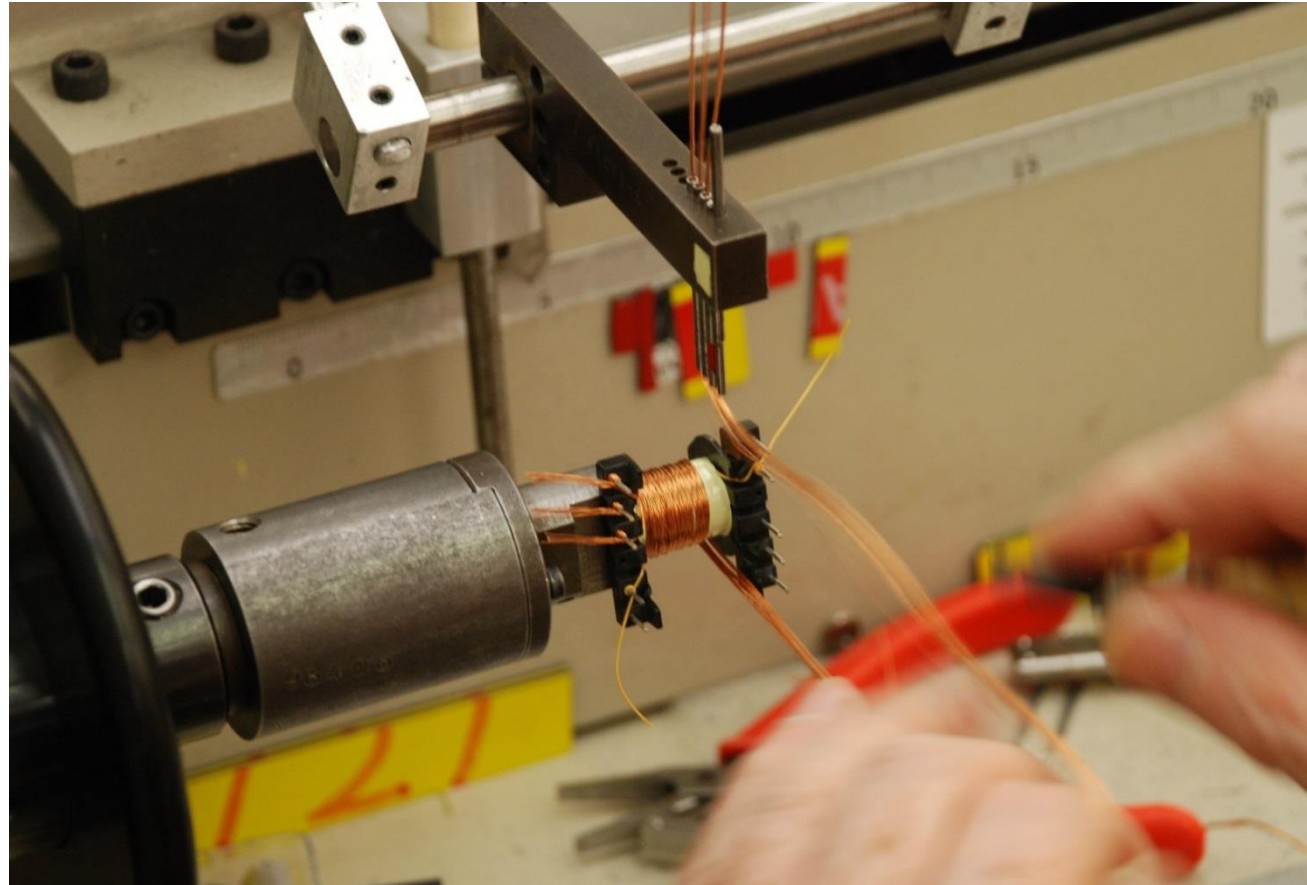
4 MAIN TRANSFORMER MANUFACTURING STEPS

1. Winding
2. Termination
3. Soldering
4. Assembly



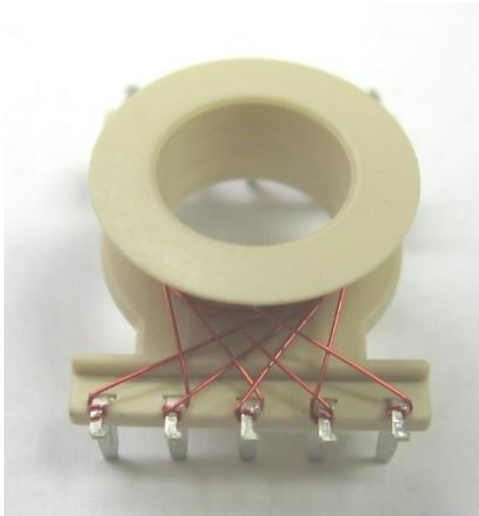
1. WINDING

- Pinout
- Dragbacks
- Layering

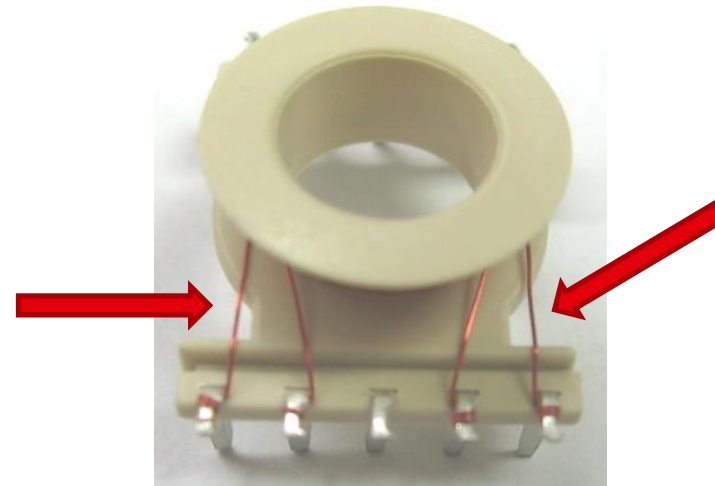


1. WINDING

Pinout



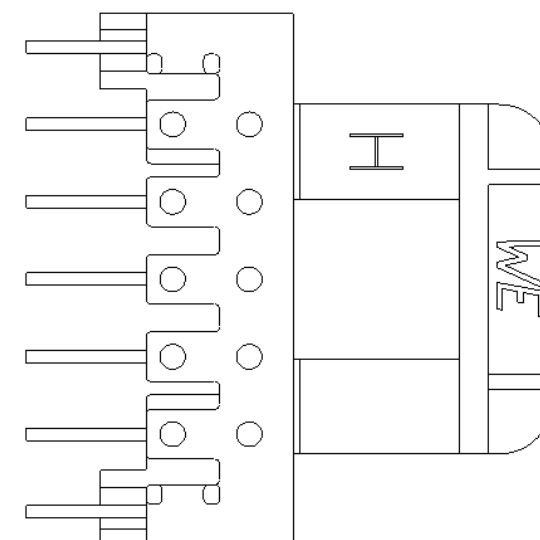
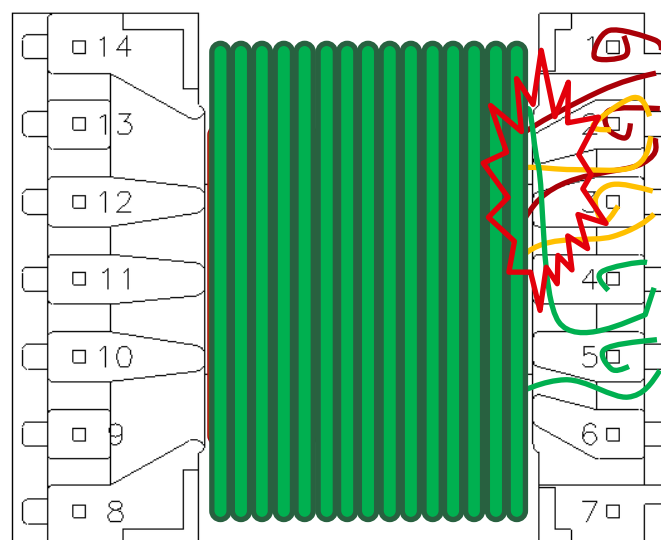
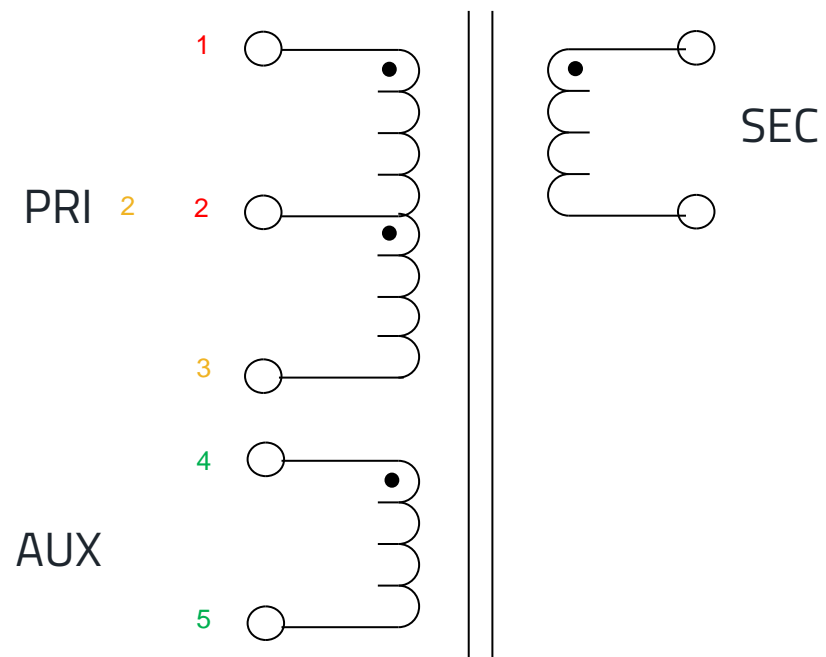
Wire crossings can cause both mechanical and dielectric stress



This is the ideal pin assignment to avoid wire crossing, but wires on external terminals can be damaged by the core.

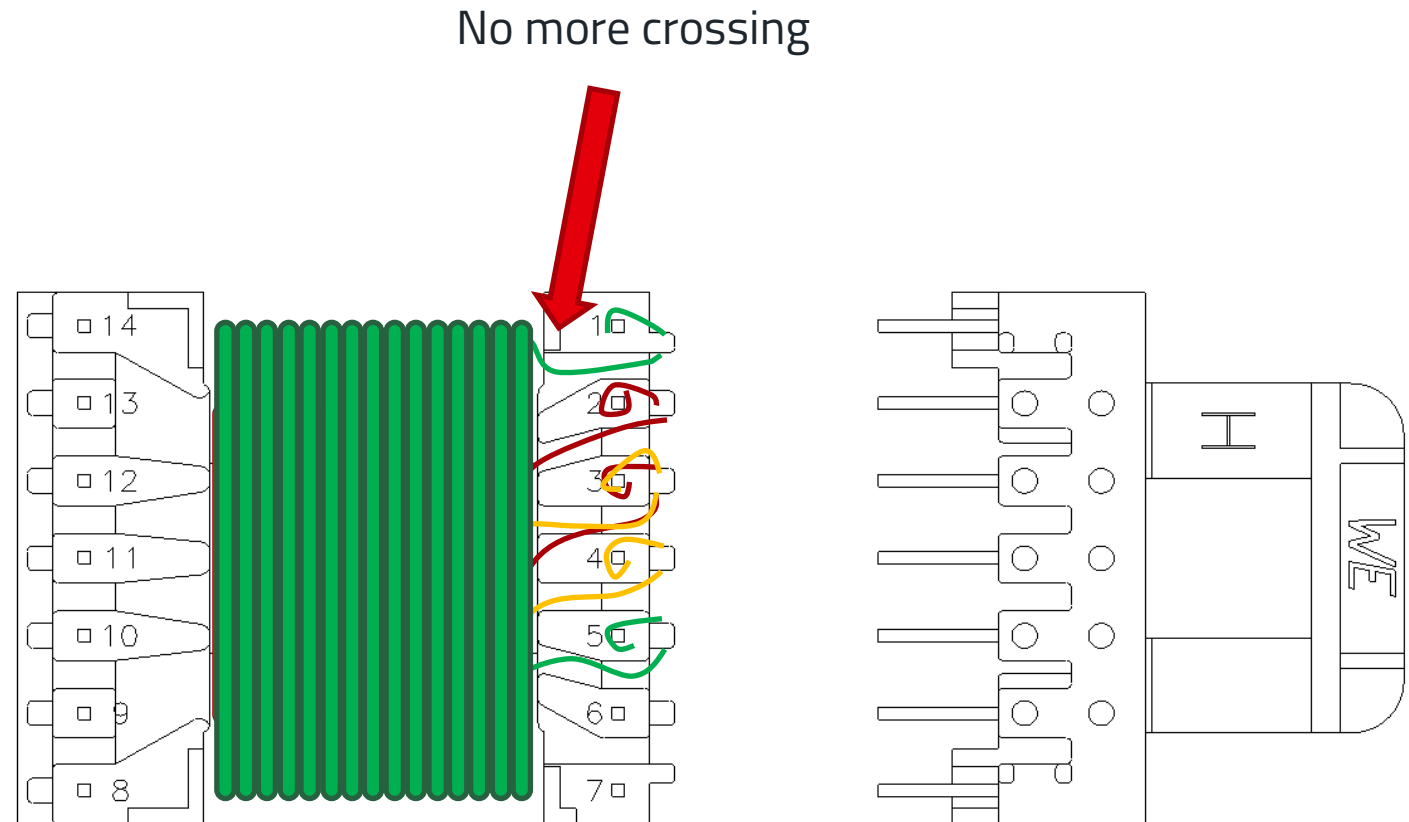
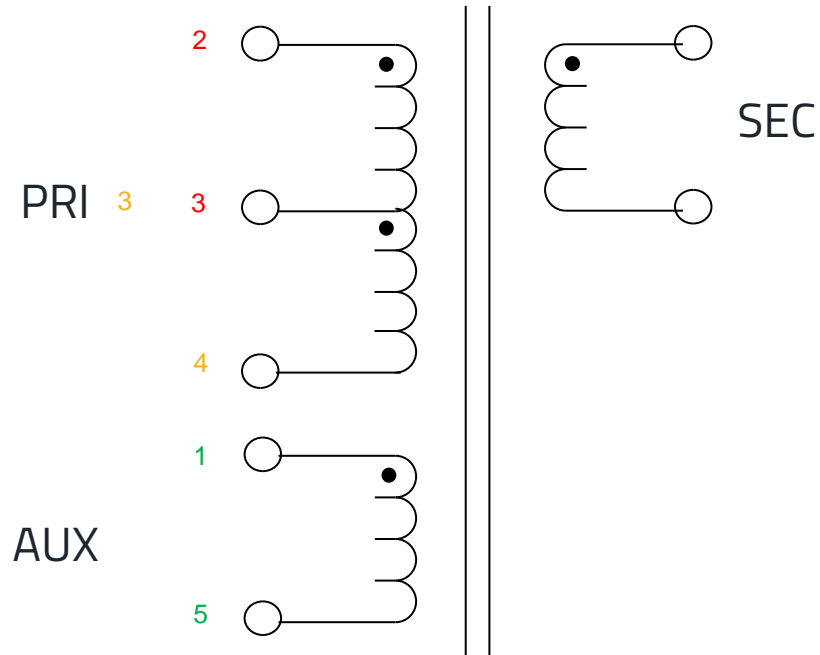
1. WINDING

Pinout



1. WINDING

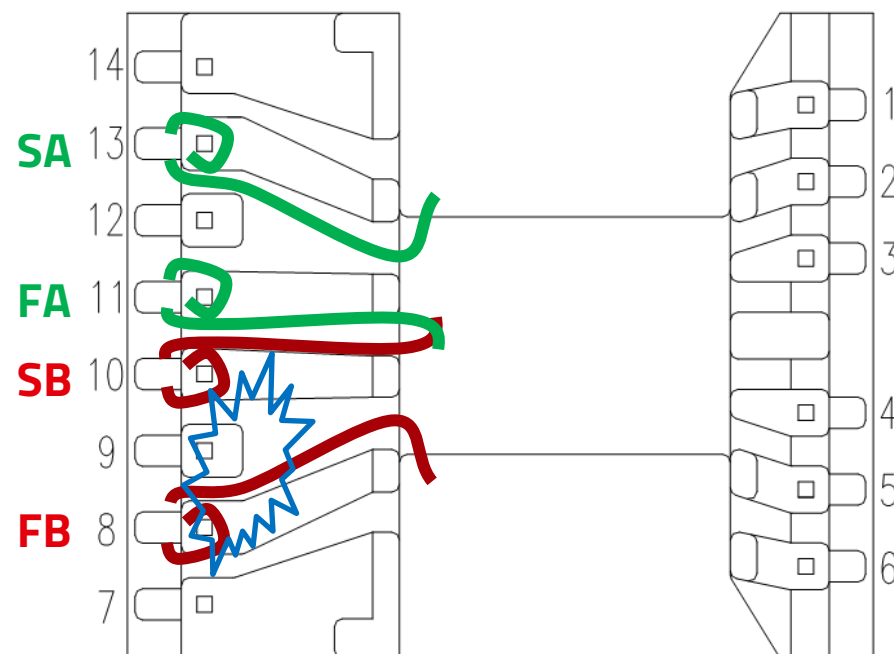
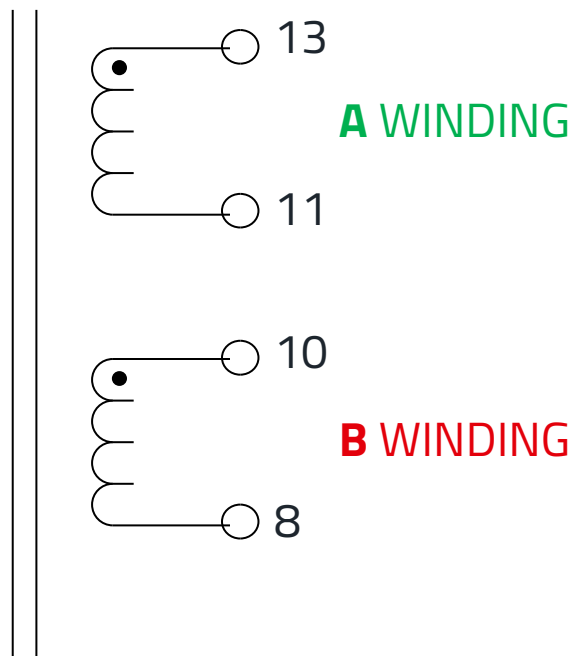
Pinout



- Freedom in choosing the best pinout
- Changes discussed together

1. WINDING

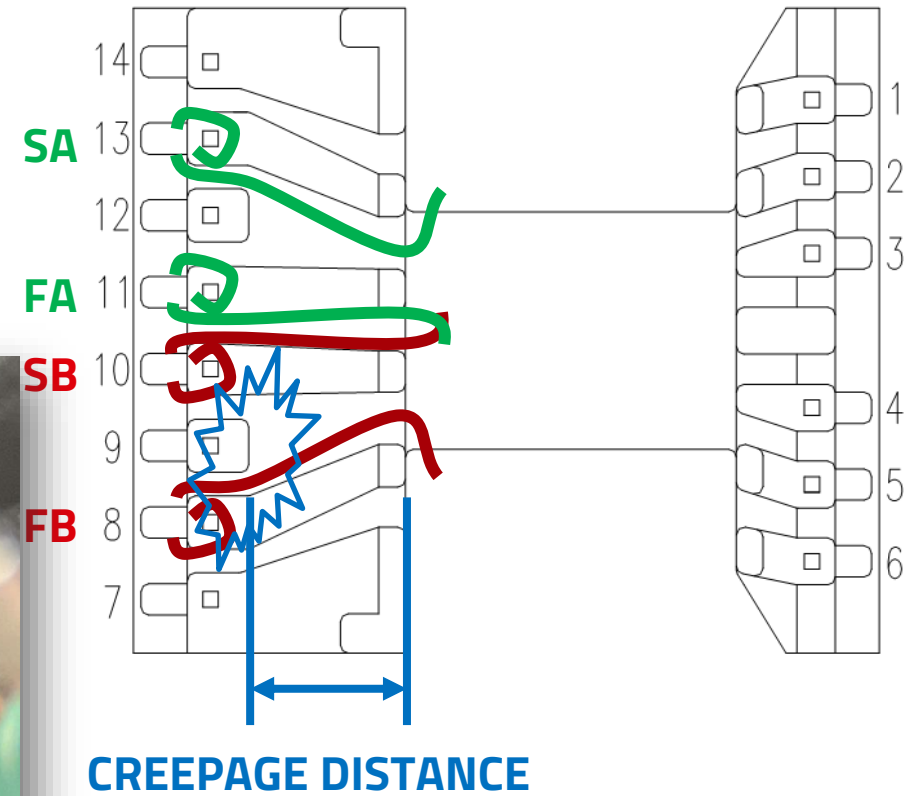
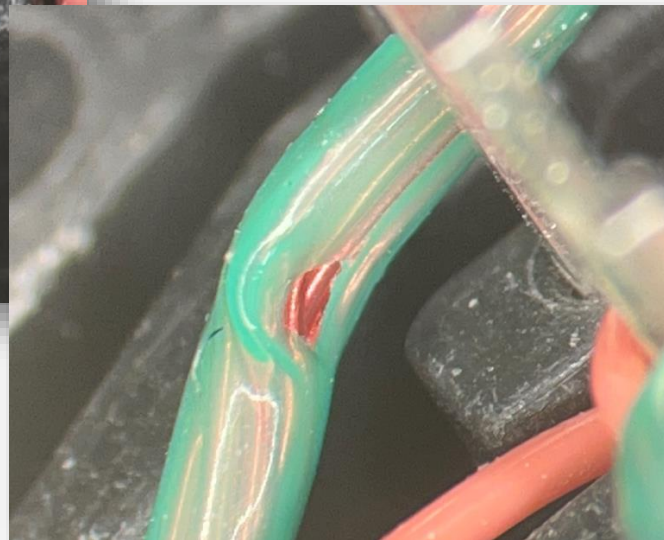
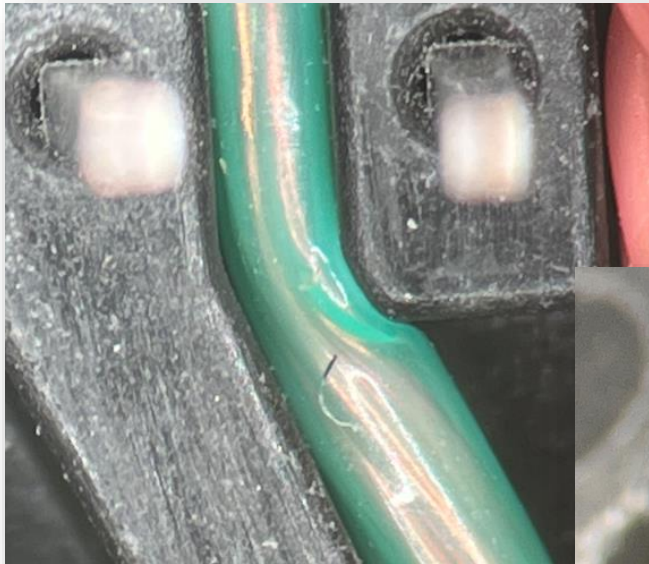
Pinout



SA: Start A
FA: Finish A
SB: Start B
FB: Finish B

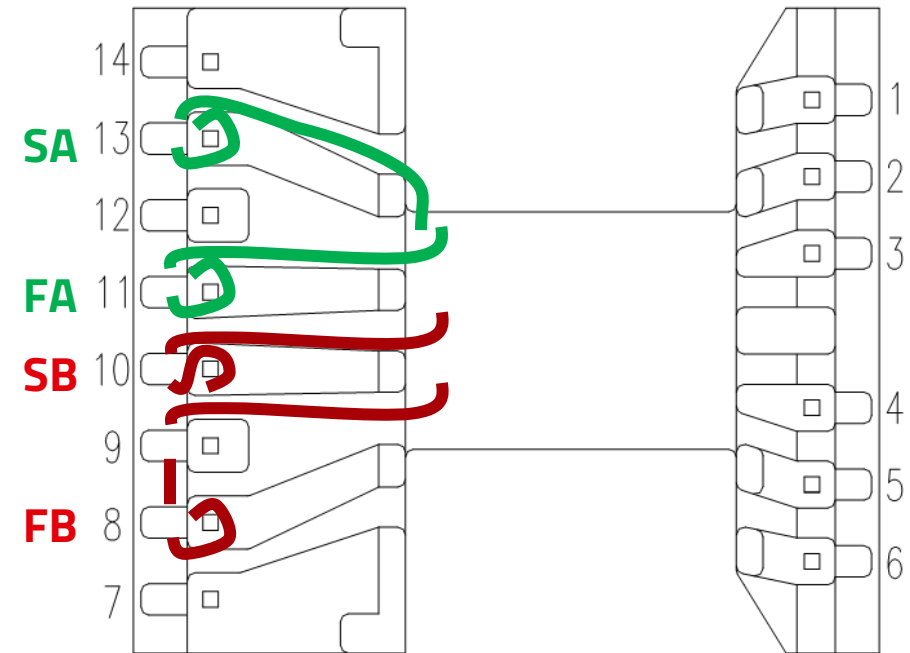
1. WINDING

Pinout



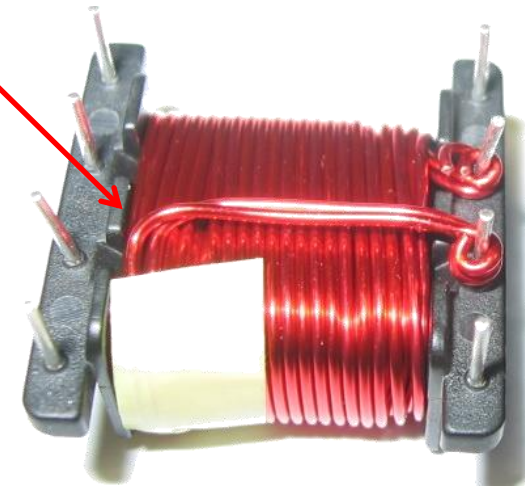
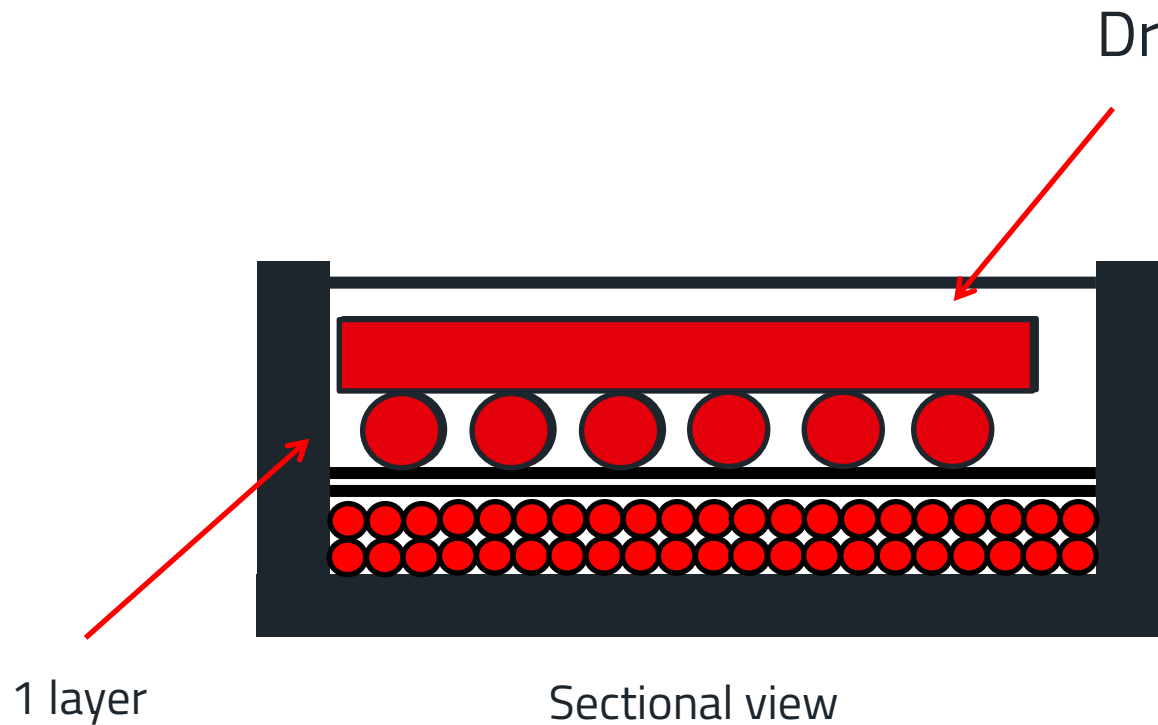
1. WINDING

Pinout



1. WINDING

Wire dragbacks

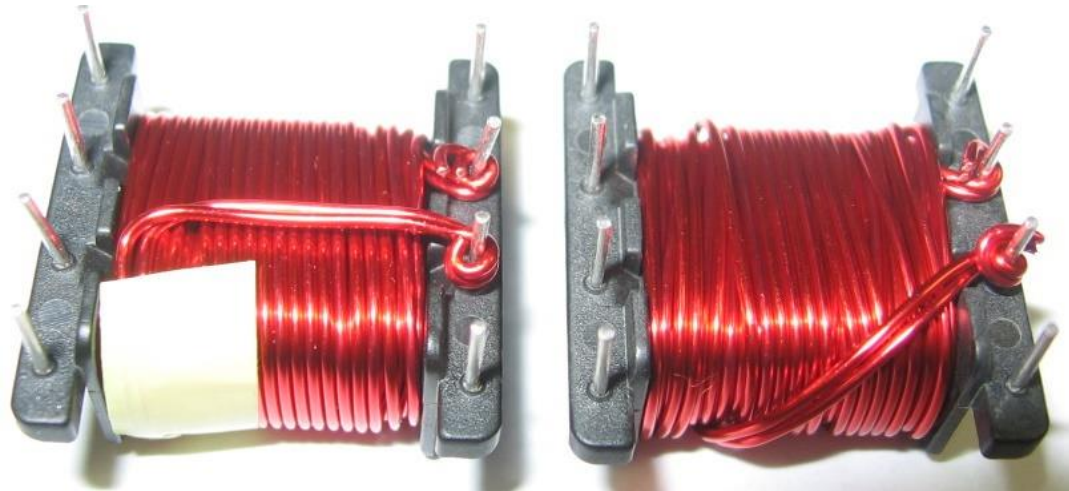


- 1, 3, 5,... layers require a dragback!
- The finish is normally at the same bobbin side as the start of the winding.

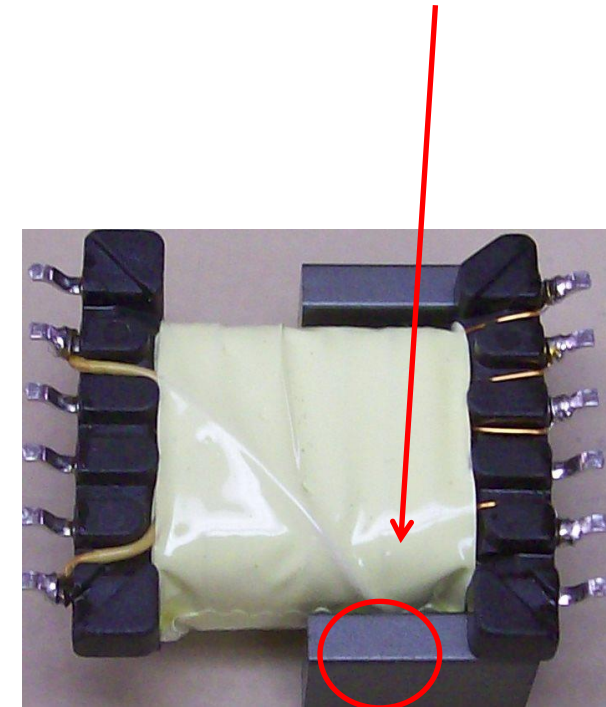
1. WINDING

Wire dragbacks

- Dragbacks can be damaged by winding pressure from subsequent layers
 - Start tape before dragback (higher labour)
- 90° dragbacks increase labor and may need extra tape
- Spiral dragbacks (easier for a winding machine) can cause core fit issues

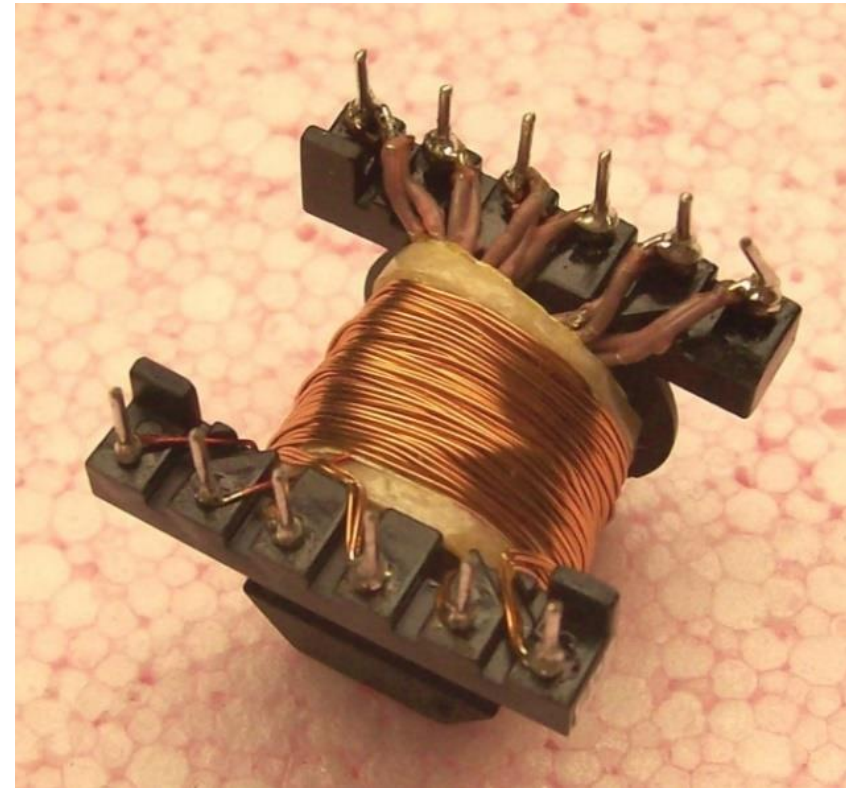


Potential core fit issue here



1. WINDING

Wire dragbacks

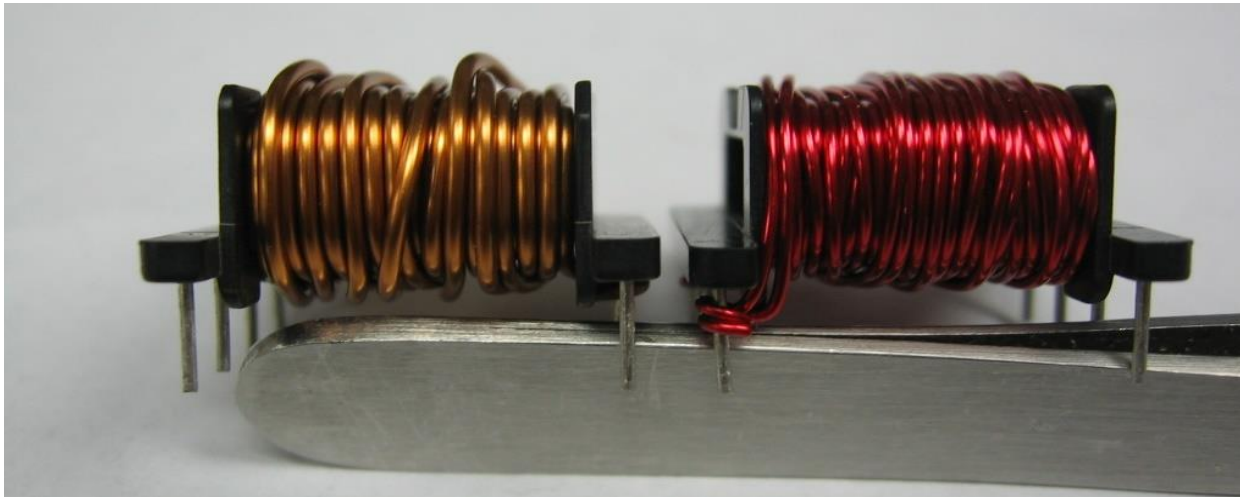


Try to avoid dragbacks!

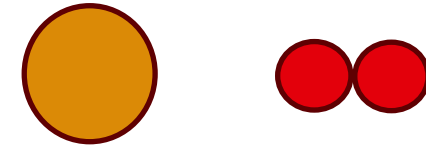
1. WINDING

Layering

- Adjust wire diameter and number of strands to fill layers



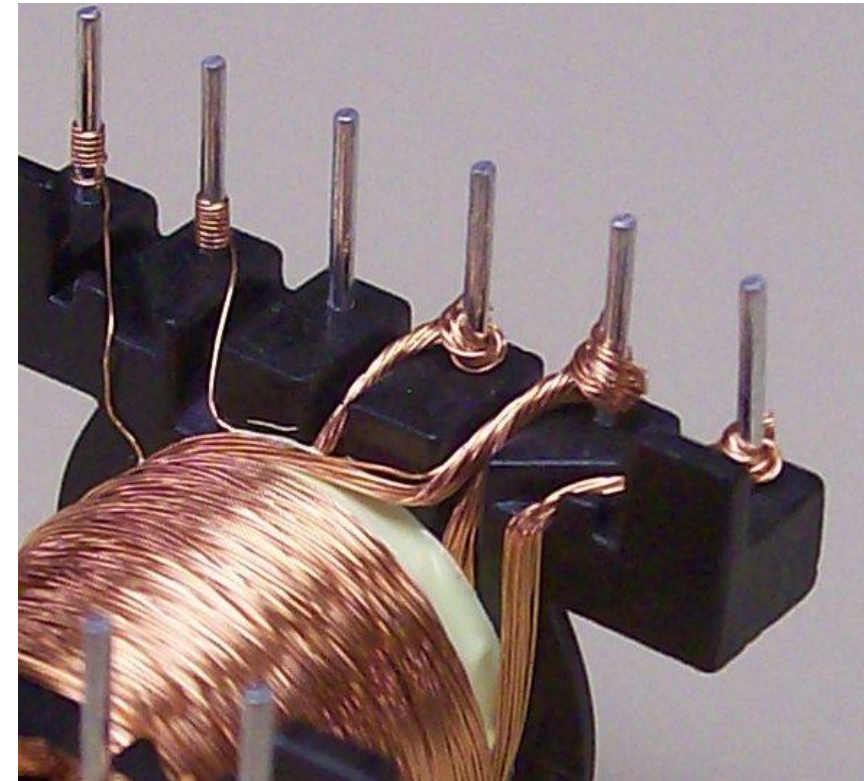
Same DC resistance,
but better layering!



- Choose pinout that promotes good layering
 - Same rail pinout for even number of layers
 - Cross bobbin pinout for odd number of layers

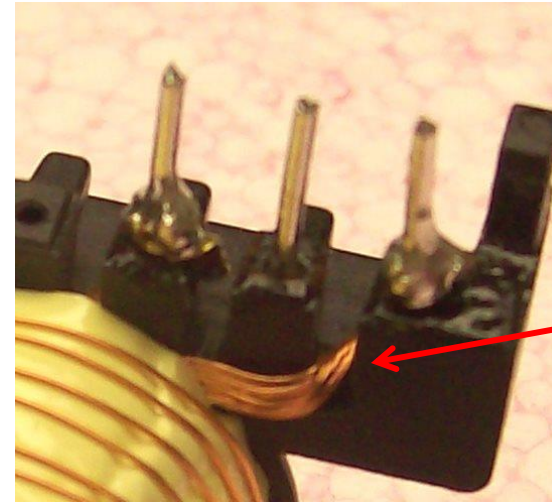
2. TERMINATION

- Heavy wire can result in exceeding the bottom surface of the bobbin.
 - Part won't sit properly on the PCB.
- Avoid heavy wire on surface mount parts.
 - Co-planarity and height issues.
 - If possible: split windings in parallel and use extra terminals for high current windings.
- Avoid heavy wires and thin wires on the same side.



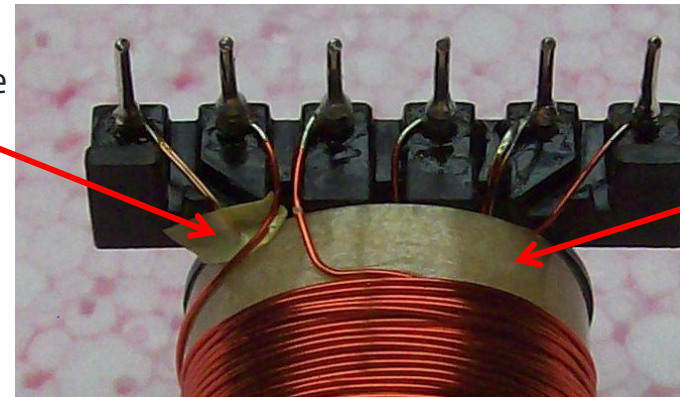
2. TERMINATION

- Crossover tape
 - Manual process
 - No consistent placement
 - Uses less winding window
- Margin tape
 - Best cost option if winding space allows
 - Very consistent
 - May increase leakage depending on layering
- Tubing
 - Effective but higher labor cost
 - Good option to for litz wire to prevent heat damage



Leadout
insulation
needed!

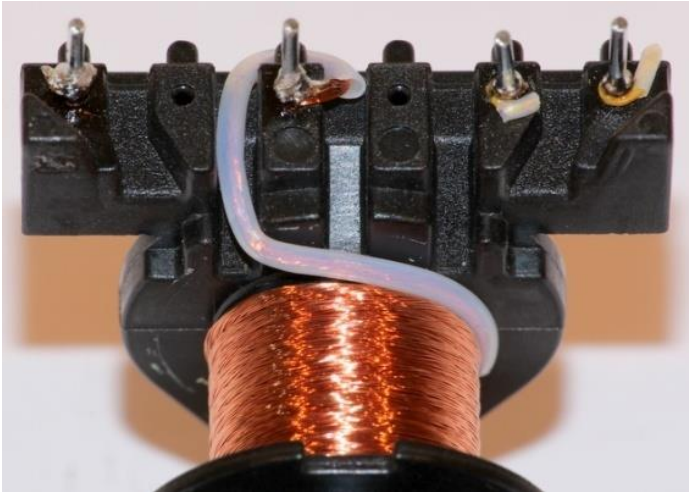
Crossover tape



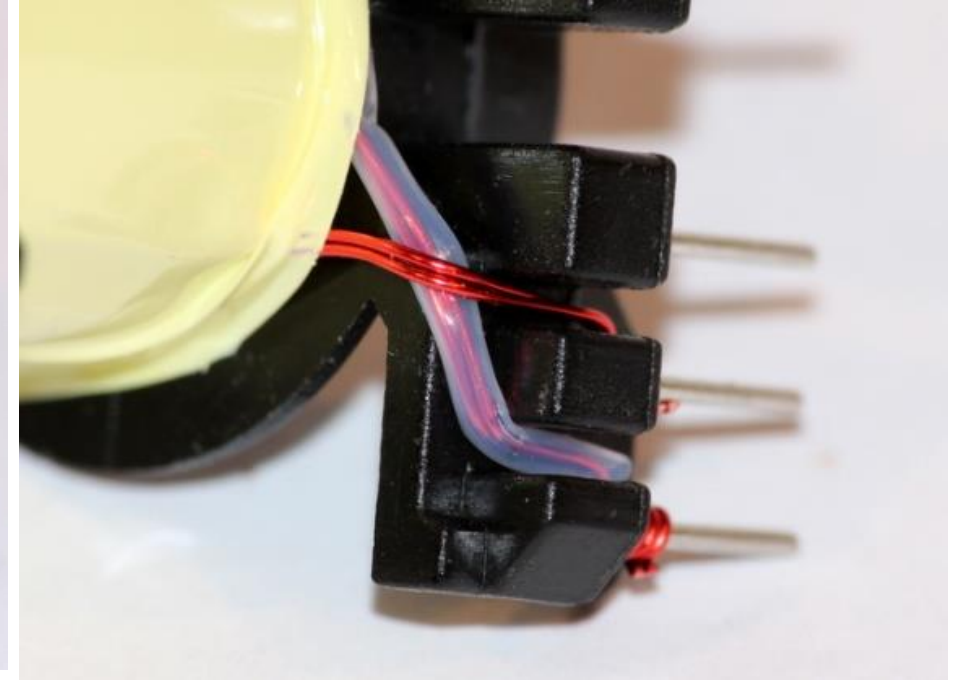
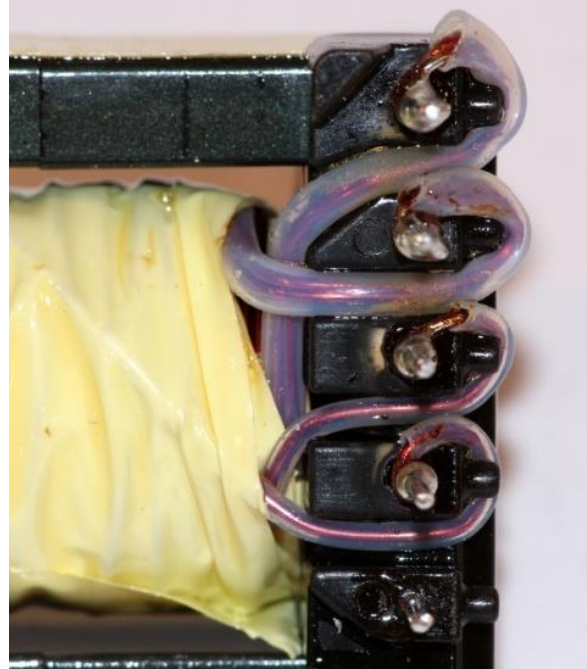
Shelf tape

2. TERMINATION

Tubing



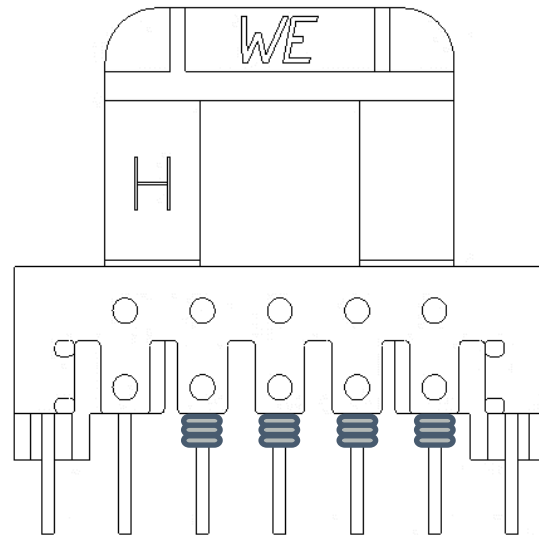
Used to increase safety distance



Used to increase distance distance and to protect the wires from crossing

3. SOLDERING

Solder bath

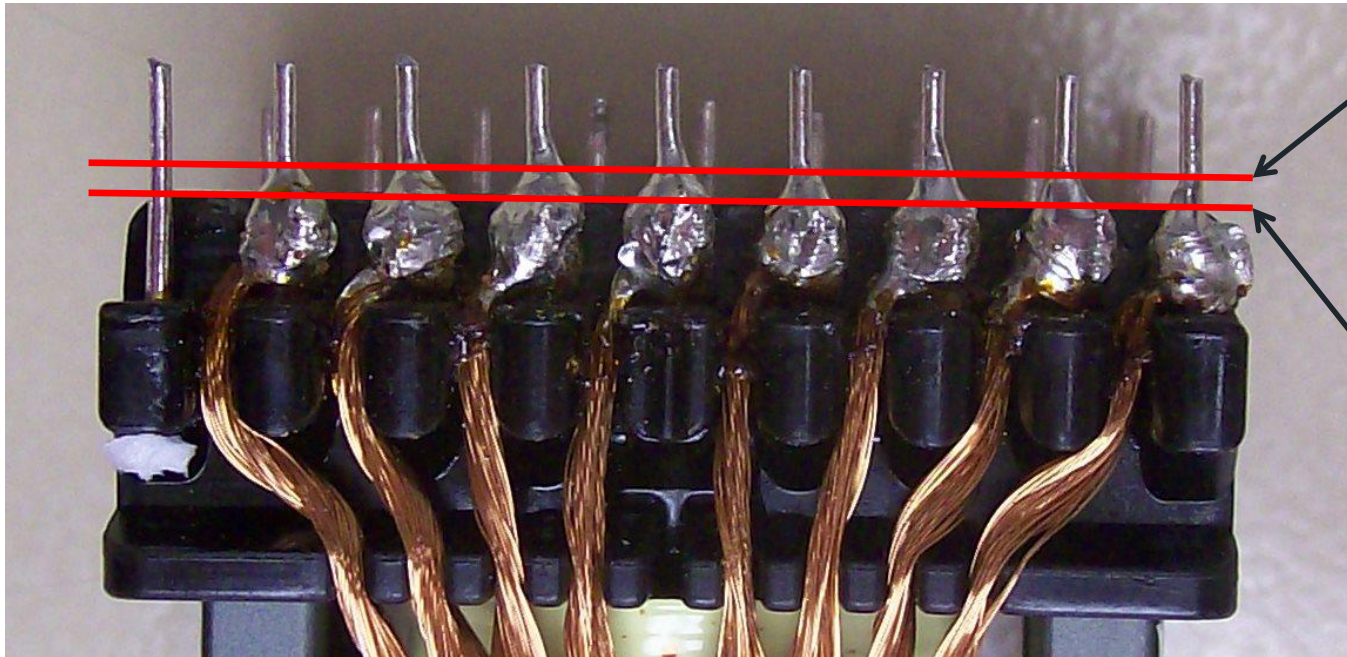


Sn96Ag4

3. SOLDERING

Solder terminations

- Large wire terminations on THT parts can cause height issues



Large Wire Wraps in
contact with PCB

Bobbin Standoff – this
surface should be in
contact with PCB

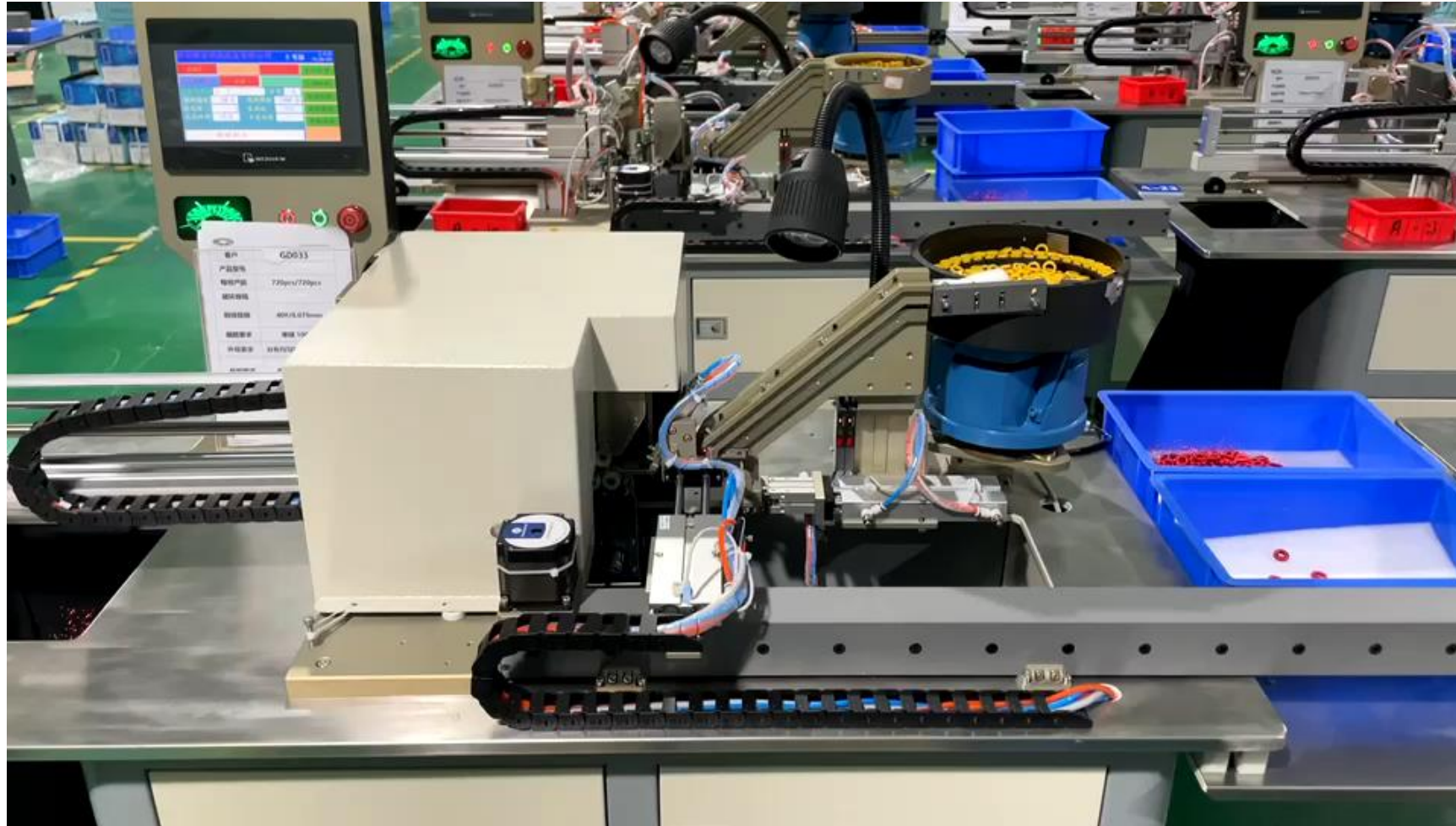
3. SOLDERING

Takeaways

- **A large single strand is more difficult to solder than multiple lighter strands**
 - Large strands: more heat, more time, causing more insulation damage
- **Avoid using heavy wire or litz wire together with fine wire windings on the same bobbin rail.**
 - Ideally, windings on same bobbin rail should be within 3 gauges (28-30AWG)
- **Sometimes it makes sense to use heavier wire than necessary– e.g. same wire for PRI and AUX, even if current density doesn't require it (also reduces BOM)**
 - If mismatch is unavoidable, we must perform soldering in two different operations.

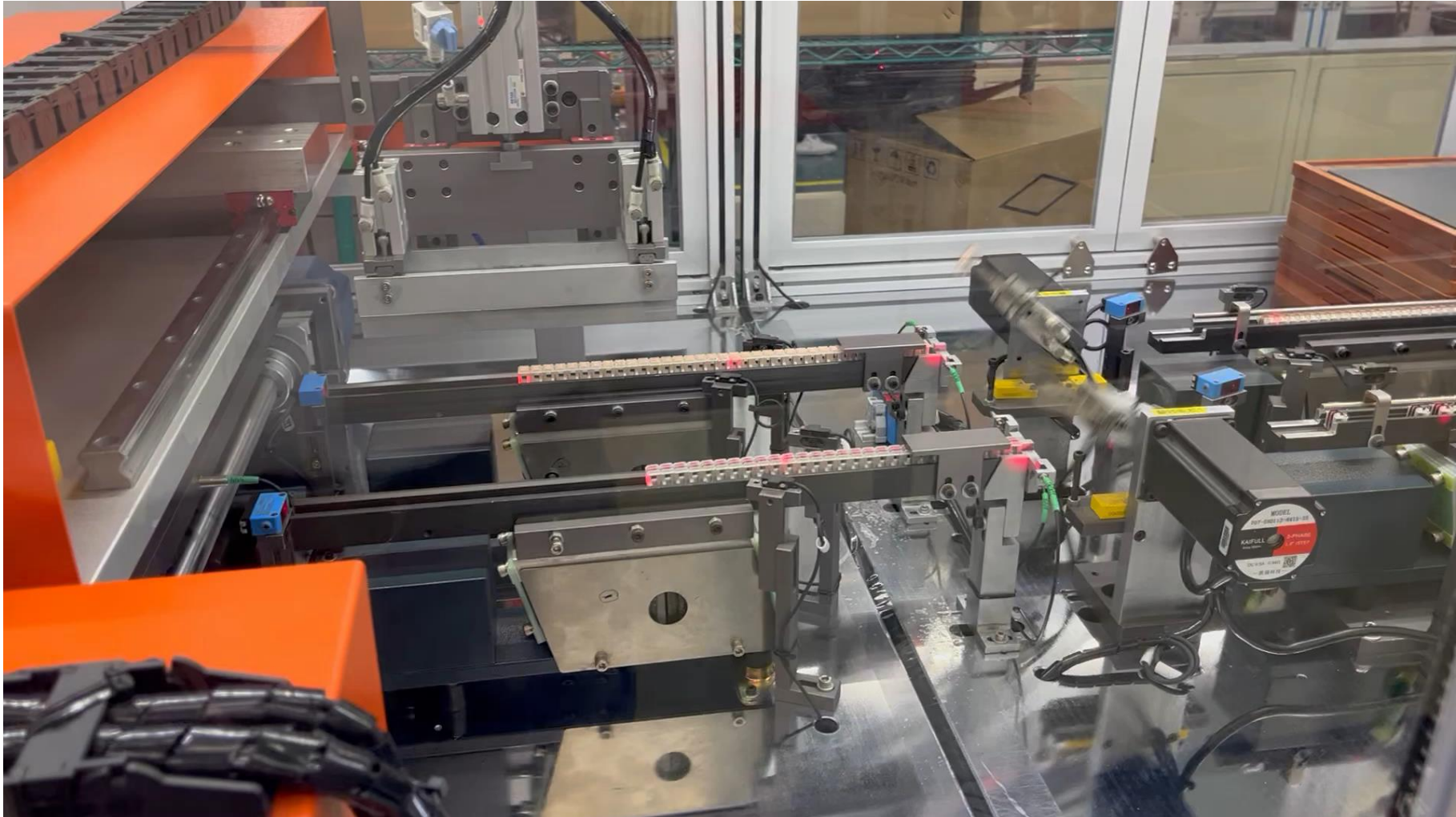
1. WINDING

Toroid winding



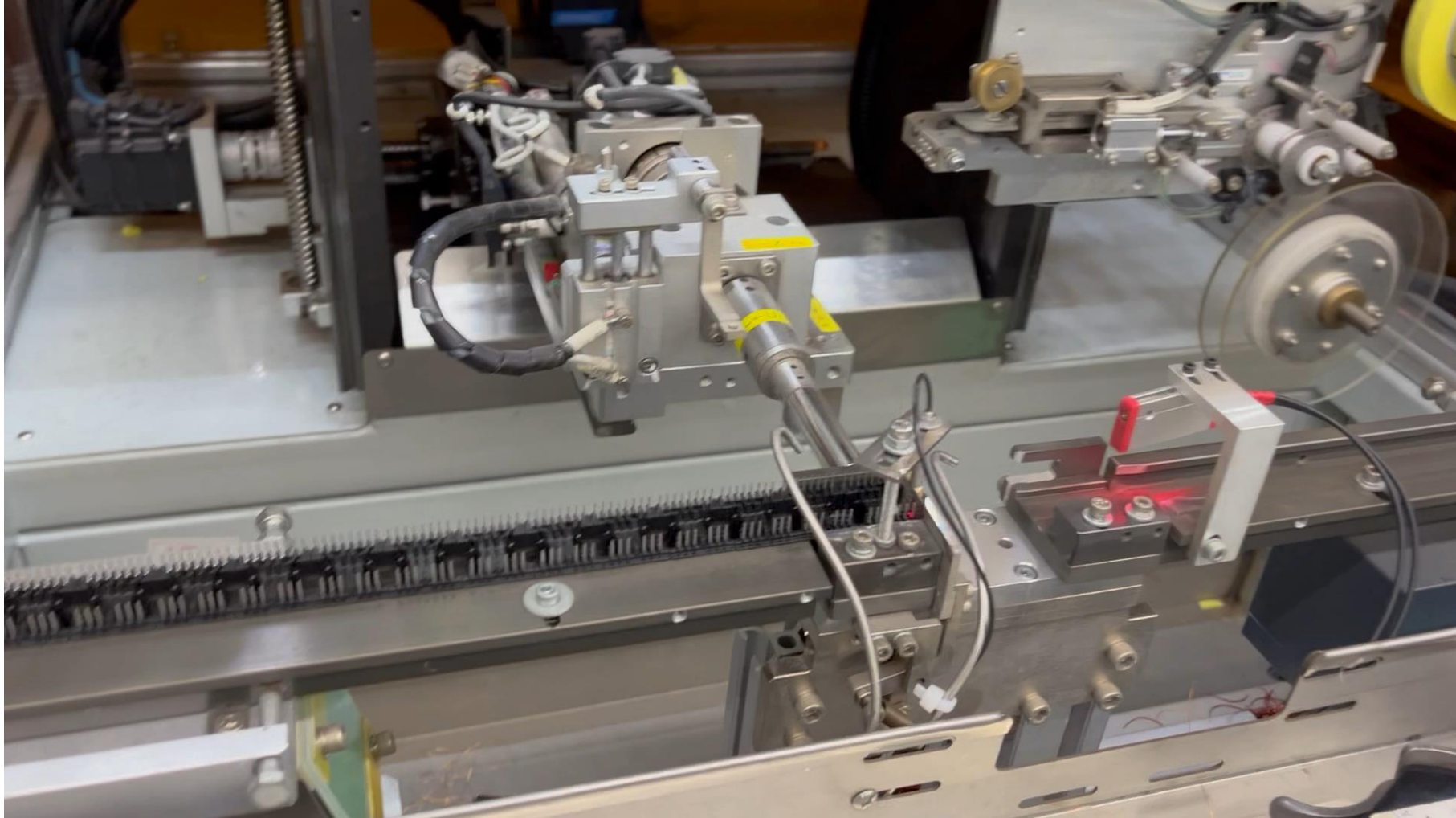
4. ASSEMBLY

Full Automatic line



4. ASSEMBLY

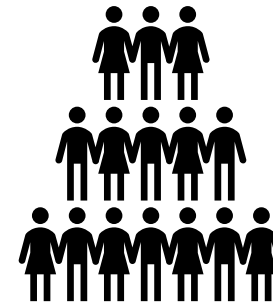
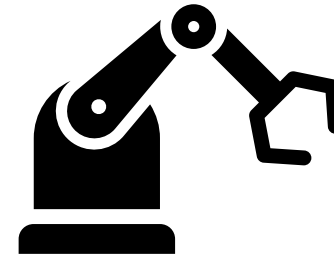
Full Automatic line



4. ASSEMBLY

Takeaways

- Fully automatic production line:
 - Mainly used material (core, bobbin, wire, tape)
 - **High change time**
 - Less human presence per production step
 - **High volume / low mix**
 - Highest reliability
- Manual production line:
 - New or special material (core, bobbin, wire, tape)
 - **Low change time**
 - More human presence is needed for every production step
 - **Low volume / high mix**
 - Medium – high reliability



SUMMARY

Why the Design for Manufacturability is important at the design stage?

- **To increase reliability**
- **To reduce cost and lead time**

Involve us as early as possible in design phase!

Questions

& Answers



We are here for you now!
Ask us directly via our chat or via E-Mail.

digital-we-days@we-online.com
Aldo.DeMichiel@we-online.de