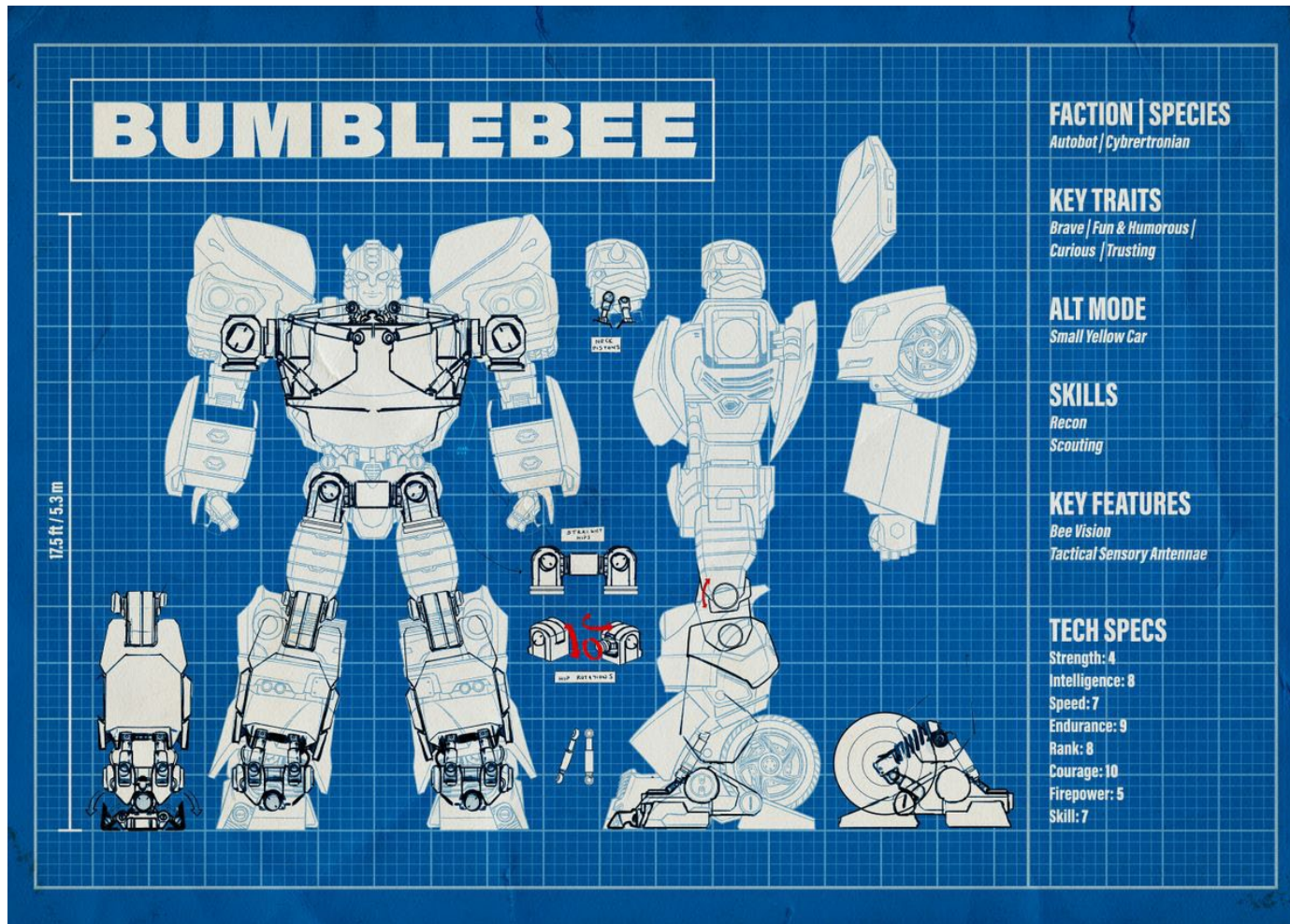




## AGENDA

- What do we need to start a custom design?
- Core selection
- How does safety affect the design?
- A showcase of our manufacturing capabilities
- Package comparison

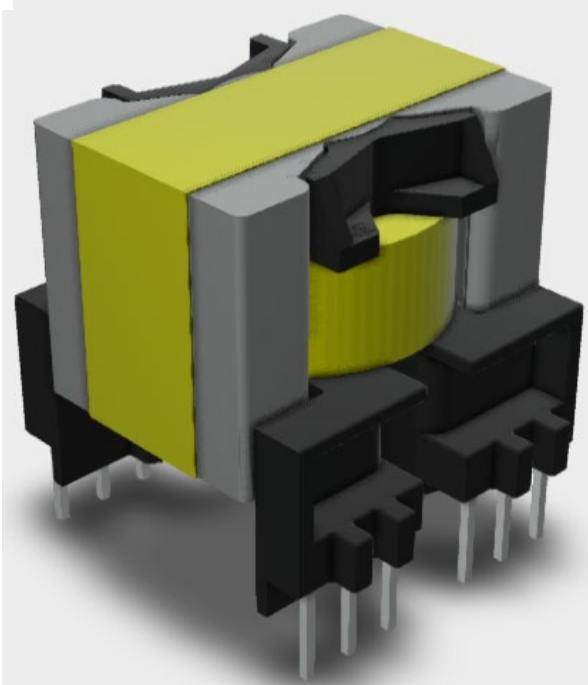
# TYPICAL TRANSFORMER CONSTRUCTION



Sorry... this is a different kind of transformer

Credits: Hasbro

# WHAT WE NEED TO BUILD A TRANSFORMER



## Other Components

Clip

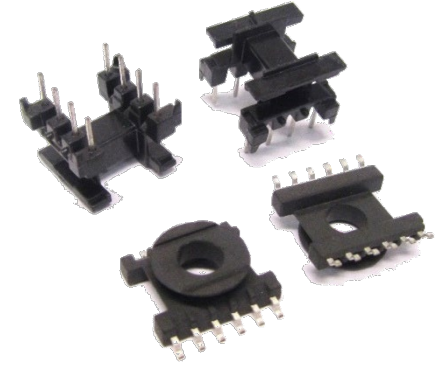
Adhesive

Varnish

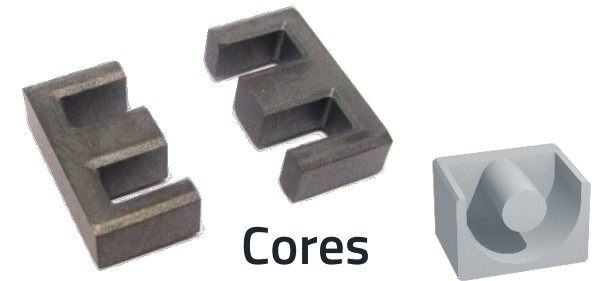
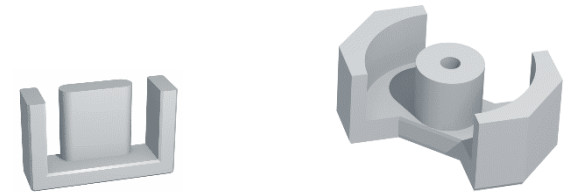
Tapes



Wires



Bobbin



Cores

# STARTING A CUSTOM DESIGN

## Inquiry form

- **Company and project info**

→ Contacts and commercial details

- **Topology & Electricals**

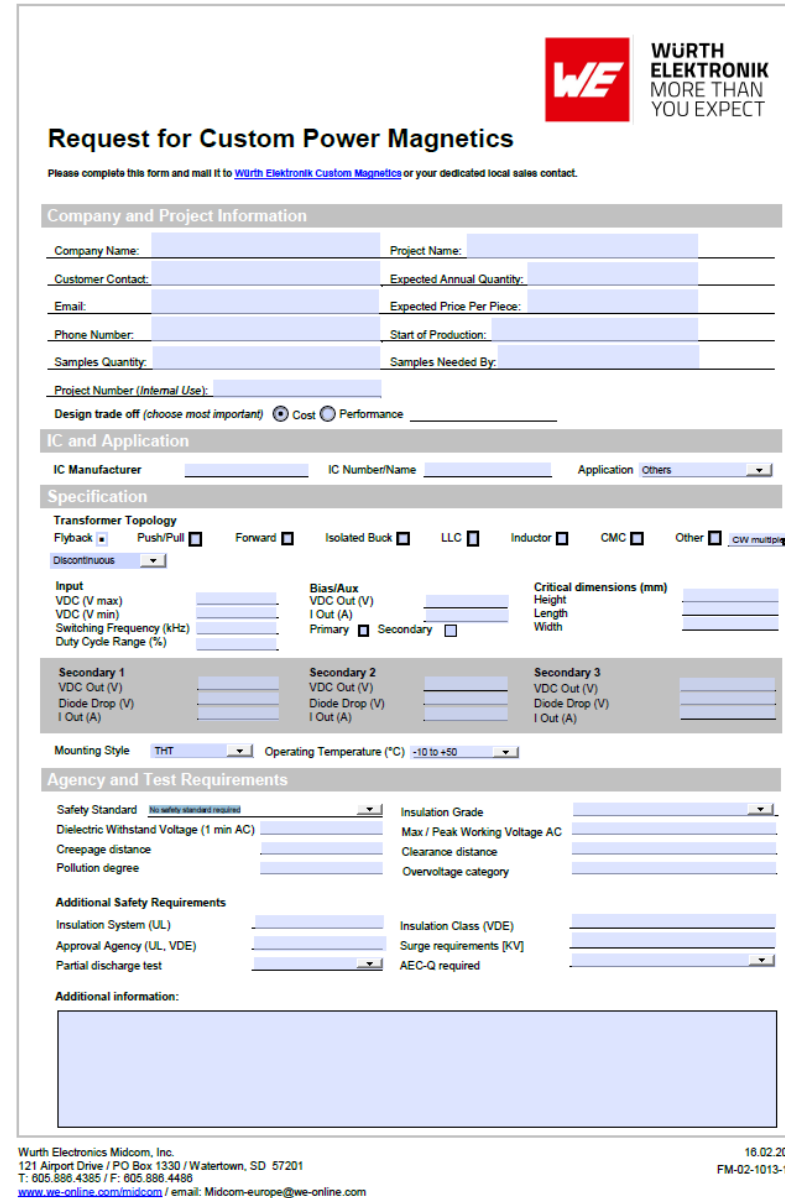
→ I/Os, ICs, Topology

- **Safety requirements?**

→ Better safe than sorry

- **Mechanical restrictions**

→ Because dimensions matter

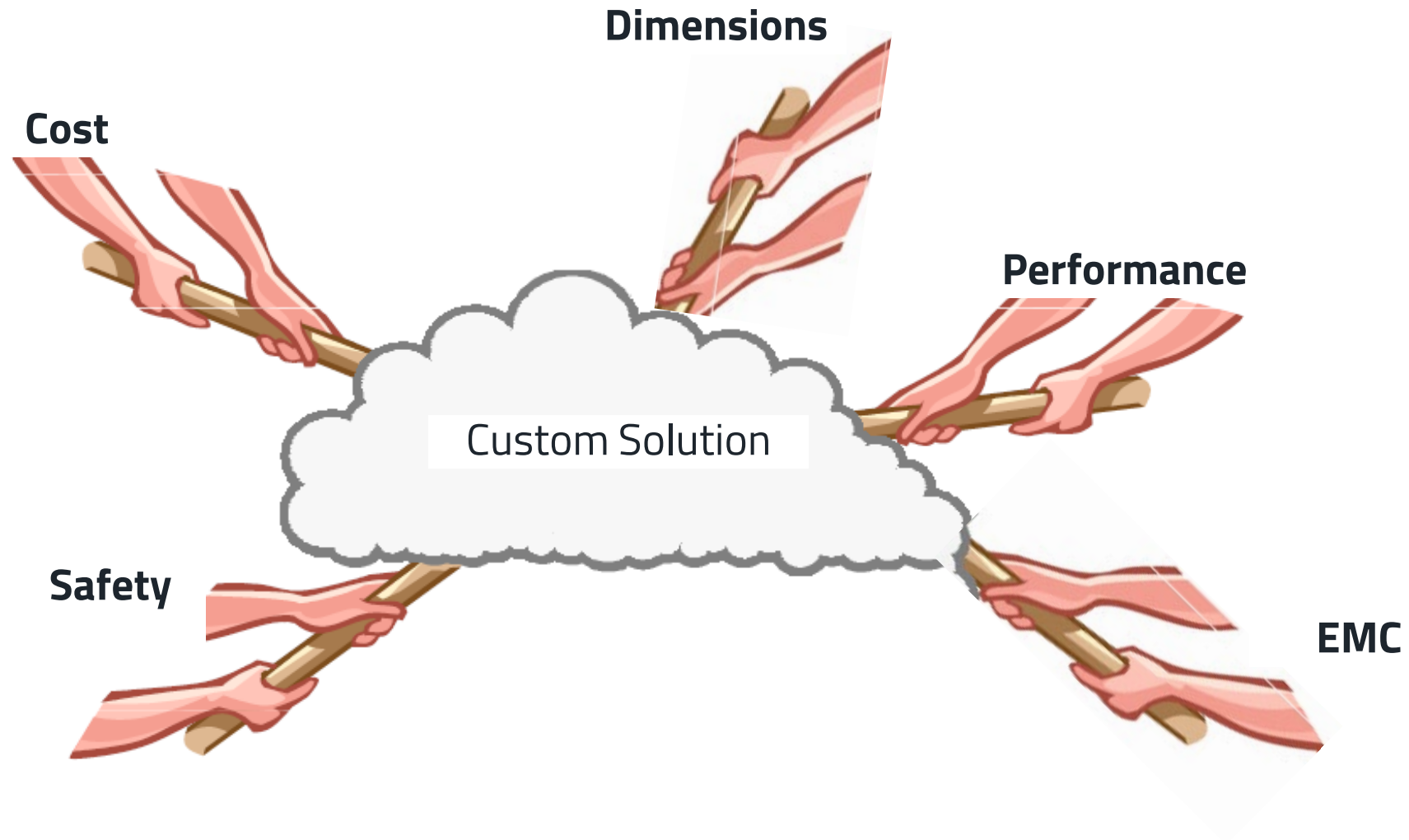


The form is titled "Request for Custom Power Magnetics" and features the Würth Elektronik logo. It is divided into several sections: "Company and Project Information" (Company Name, Project Name, Customer Contact, Expected Annual Quantity, Email, Expected Price Per Piece, Phone Number, Start of Production, Samples Quantity, Samples Needed By, Project Number), "IC and Application" (IC Manufacturer, IC Number/Name, Application), "Specification" (Transformer Topology: Flyback, Push/Pull, Forward, Isolated Buck, LLC, Inductor, CMC, Other; Input: VDC, V min, Switching Frequency, Duty Cycle Range; Bias/Aux: VDC, I Out, Primary/Secondary; Critical dimensions: Height, Length, Width; Secondary 1, 2, 3: VDC Out, Diode Drop, I Out; Mounting Style: THT; Operating Temperature: -10 to +50), "Agency and Test Requirements" (Safety Standard, Dielectric Withstand Voltage, Creepage distance, Pollution degree, Insulation Grade, Max / Peak Working Voltage AC, Clearance distance, Overvoltage category, Additional Safety Requirements: Insulation System, Approval Agency, Partial discharge test, Insulation Class, Surge requirements, AEC-Q required), and "Additional information" (a large text area). The footer contains contact information for Würth Electronics Midcom, Inc. and the date 16.02.2022.

More details in the  
[Inquiry Form](#)

# STARTING A CUSTOM DESIGN

Initial considerations



# PACKAGE CHOICE

Criteria that impact the choice of a package

- **Shape:** Vertical or horizontal / SMD or THT versions (Different Footprint)
- **Cost:** Automated winding & Assembly
- **Safety:** standards and safety distances
- **EMI:** Some core shapes offer excellent shielding
- **Power:** Core  Design starting point
- **Pick and Place:** Flat surface / Clip / Cap

## CORE SELECTION OVERVIEW

### Basic Rule

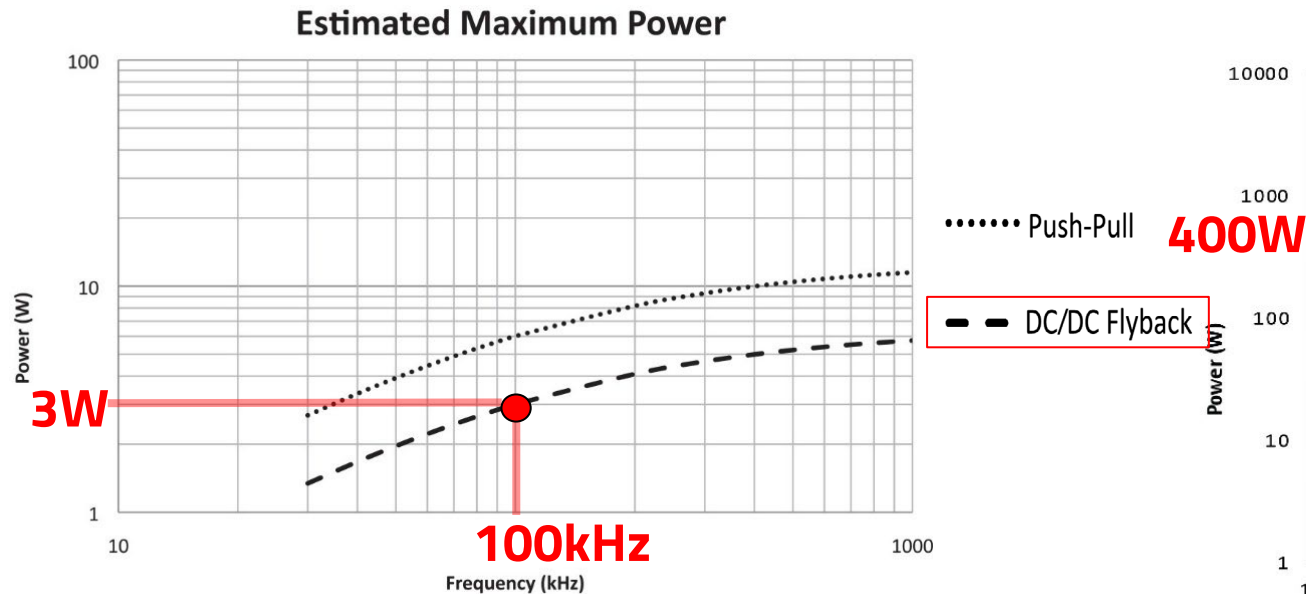


# CORE SELECTION

Example: Low Power vs High Power core

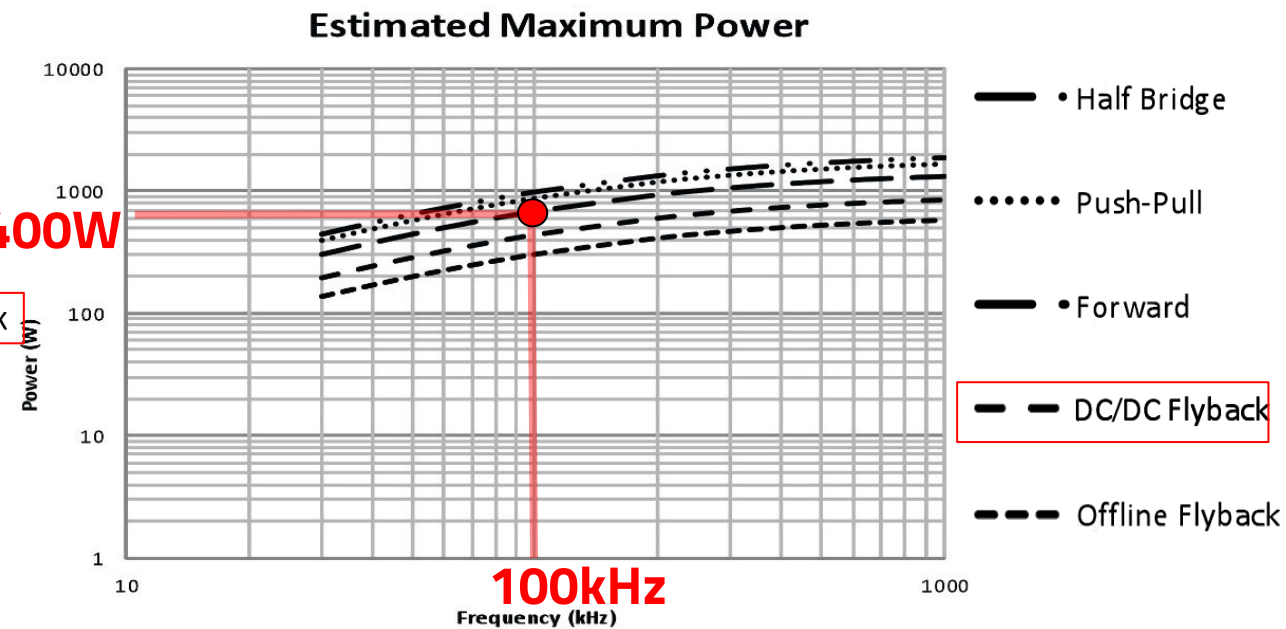
## Low Power

EP7: DC-DC flyback @100kHz:



## High Power

ETD39: DC-DC flyback @100kHz:



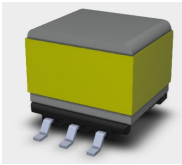
Graph Source:  
Würth Elektronik ["Customs Capability Catalogue"](#)

# CORE SELECTION

Example: Low Power vs High Power core

## Low Power

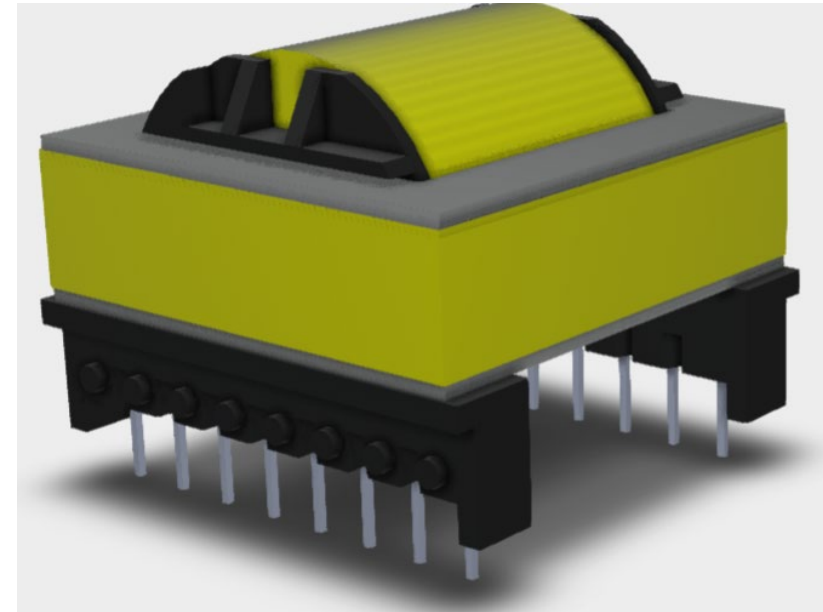
EP7: DC-DC flyback @100kHz:



**Max achievable: 3W**

## High Power

ETD39: DC-DC flyback @100kHz:



**Max achievable: 400W**

Graph Source:  
Würth Elektronik ["Customs Capability Catalogue"](#)

# HOW DOES SAFETY AFFECT THE TRANSFORMER?

## Common safety standards

What are safety standards?

- Mechanical and electrical precautions to protect the user in risk of fire, electrical shock & injuries
- IEC 62368-1 → Audio Video and Information Technology Equipment (Replacing IEC-60950 & IEC-60065)
- **IEC 61558-1 → Safety of power transformer and general Power Supply**
- IEC 61010-1 → Safety of Measurements control and laboratory equipment
- IEC 60601-1 → Safety of Medical Equipment



**Main safety agencies**

# HOW DOES SAFETY AFFECT THE TRANSFORMER ?

Minimum Information to calculate Creepage and Clearance distances

- Insulation Grade
- Overvoltage Categories
- Pollution Degree
- Altitude (if >2000m)
- Max / Peak working voltage

## WE Midcom Inquiry form:

| Agency and Test Requirements            |                                                                                 |                               |                 |
|-----------------------------------------|---------------------------------------------------------------------------------|-------------------------------|-----------------|
| Safety Standard                         | 61558 - Safety of transformers, reactors, power supply units and combinations ▾ | Insulation Grade              | Supplementary ▾ |
| Dielectric Withstand Voltage (1 min AC) |                                                                                 | Max / Peak Working Voltage AC | 375             |
| Creepage distance                       |                                                                                 | Clearance distance            |                 |
| Pollution degree                        | 2                                                                               | Overvoltage category          | 2               |

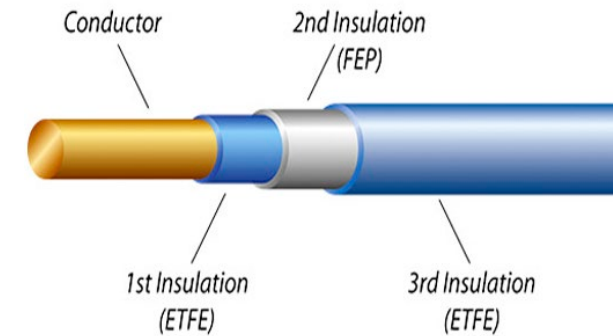
If the form is not filled out, we will contact you 😊



# HOW DOES SAFETY AFFECT THE TRANSFORMER ?

## Insulation grades

- Functional Insulation: only proper functioning of the equipment. (**"0" layers**)
- Basic Insulation: a certain protection against electric shock (**1 Layer**)
- Supplementary Insulation: A higher solid insulation (**2 Layers**)
- Reinforced insulation: Generally using triple insulated wire (**3 Layers**)



Example: Triple Insulated Wire (TIW)

→ **3 layers of insulation: Reinforced**

**In general:**

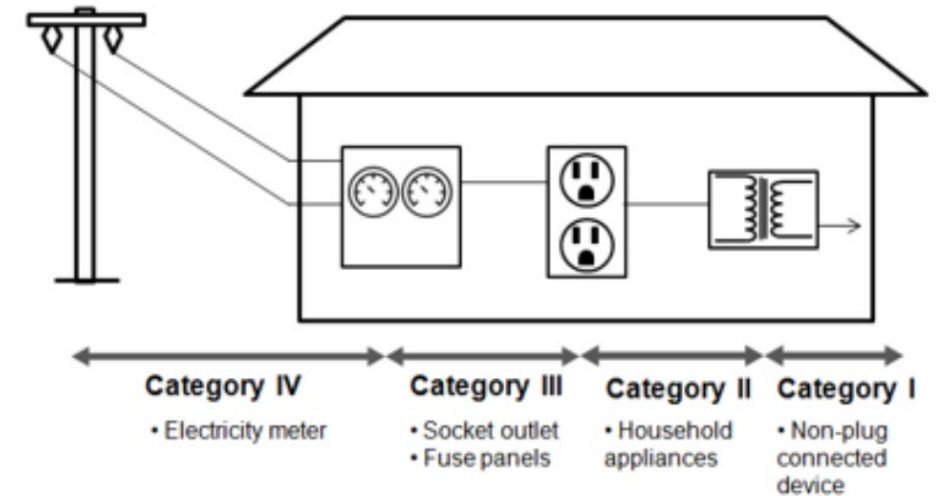
→ **The higher the Insulation grade**

→ **The lower the space available for the windings**

# HOW DOES SAFETY AFFECT THE TRANSFORMER ?

## Overvoltage category

Short story: Voltage Spikes / Voltage transients



**The higher the Overvoltage Category:**  
→ **Higher distance between PRI & SEC**  
→ **Worse coupling**  
→ **Bigger transformer**

  
Greater chance of voltage spikes and transients

# HOW DOES SAFETY AFFECT THE TRANSFORMER ?

## Pollution degree

- Pollution degree 1: No pollution that can influence the insulation.  
→ Example: Complete encapsulation



<https://gluespec.com>

- Pollution degree 2: Non-conductive pollution occurs.  
→ Example: the Office



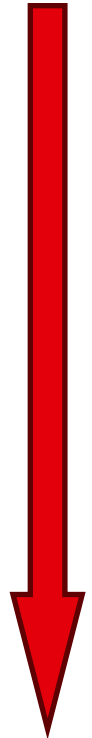
<https://www.usmagazine.com/celebrity-news>

- Pollution degree 3: Conductive pollution degree occurs.  
→ Example: Harsh industrial environment



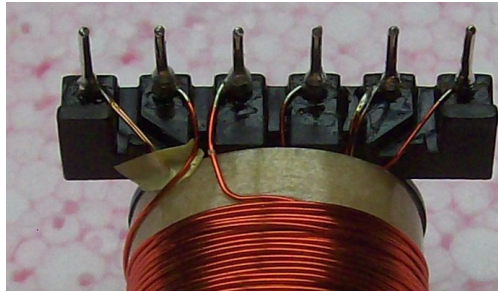
<https://wp.scoopwhoop.com>

**Safety  
distance  
needed**



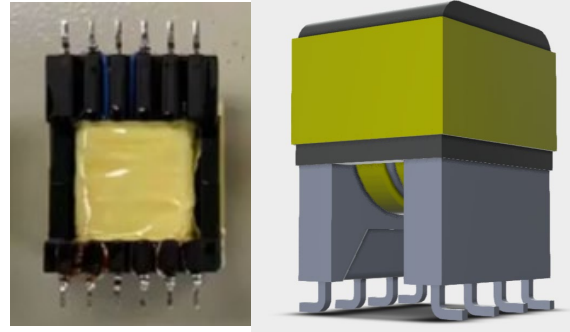
# DESIGN TECHNIQUES TO MEET SAFETY

Examples of how to meet creepage and clearance distances:



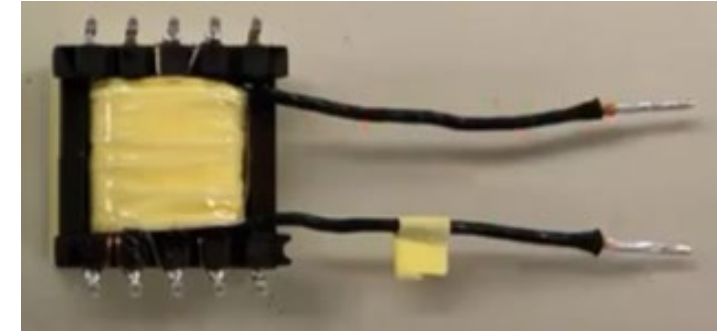
## Margin tape

- ☹️ Bad for performances
- 😊 Compact solution



## Extended Rail Bobbin

- ☹️ Part is bigger
- 😊 Easier Manufacturing



## Flying leads (Avoid when possible)

- ☹️ ☹️ Bad for manufacturing & assembly on the PCB
- 😊 Long distances achievable

Curious about Design For Manufacturing? Webinar: [Design For Manufacturing \(DFM\)](#)

# HOW DOES SAFETY AFFECT THE TRANSFORMER?

Safety or no Safety? That's the question!

|                           | Functional | Basic/Reinforced |
|---------------------------|------------|------------------|
| Size                      | 😊          | 😞                |
| Efficiency                | 😊          | 😞                |
| Manufacturing             | 😊          | 😞                |
| Cost                      | 😊          | 😞                |
| High Dielectric withstand | 😞          | 😊                |

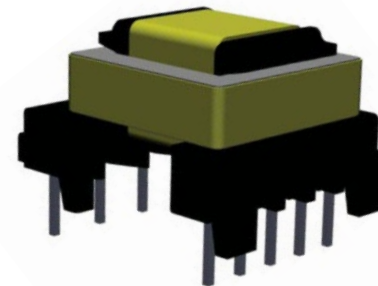
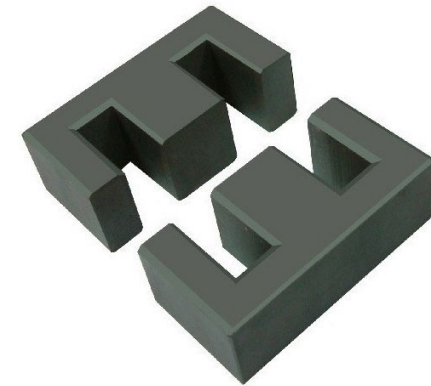
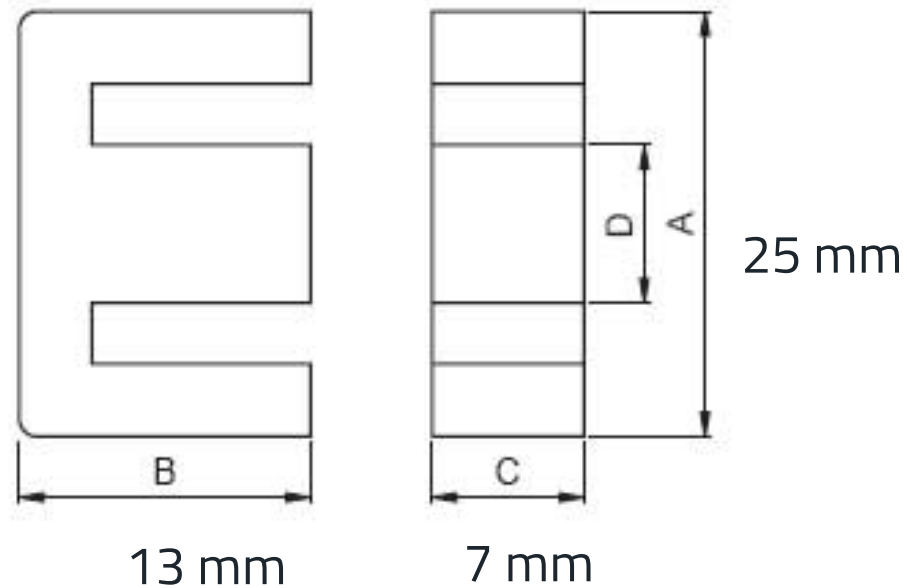
Curious about safety in power transformers? Webinar: [How does safety affect your design?](#)

Let's see now some packages...

# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

Example: Definition and Package Naming

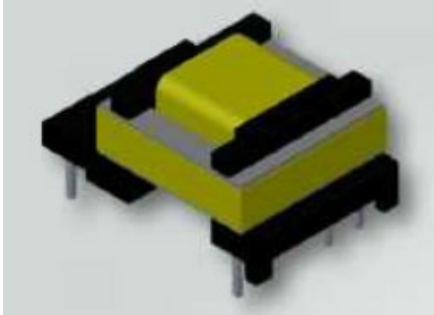
EE 25/13/7



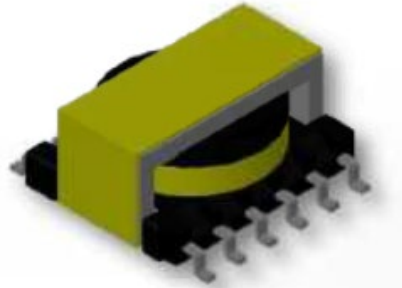
Quiz: How many packages do you know? What is your favorite one?

# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

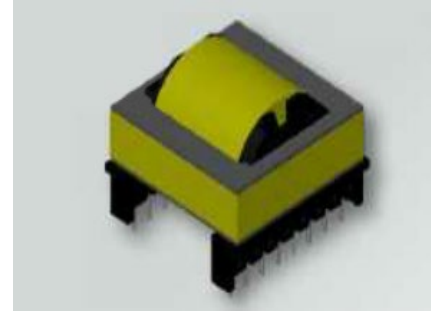
## Common Package Styles for WE MIDCOM



EE Package Style  
(2 E cores)



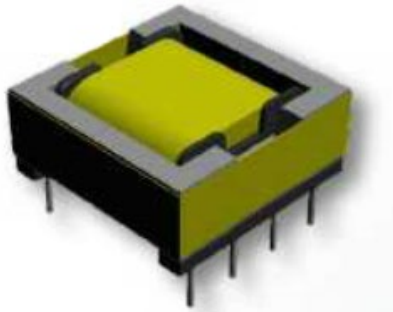
ER Package Style  
(E – Round core)



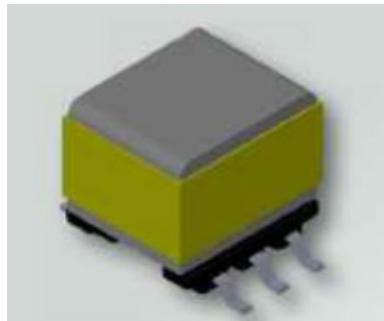
ETD Package Style  
(Economic  
Transformer design)



RM Package Style  
(Rectangular  
Module)



EFD Package Style  
(Economic Flat Design)



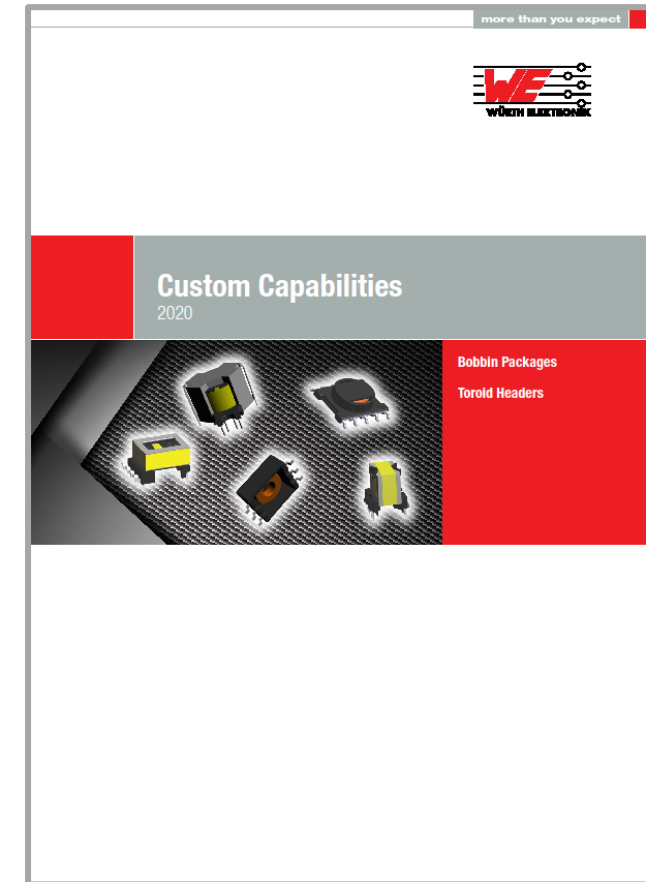
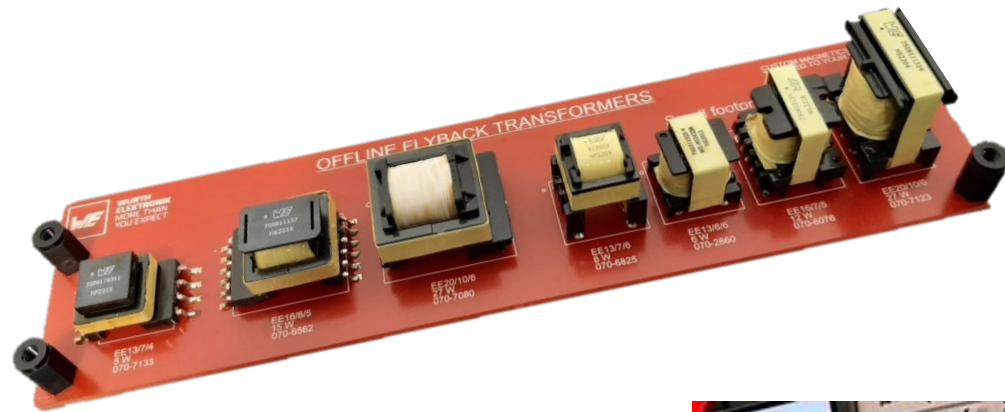
EP Package Style  
(Mix E – Pot core)



PQ Package Style  
(Power & Quality)

Credits to: <https://www.linkedin.com/pulse/alfs-musings-7-alfonso-mart%C3%ADnez-de-la-torre/>

# PACKAGE SELECTION - EXAMPLES



(More here ☺ [CUSTOM CAPABILITIES CATALOG](#))

# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

## EP Package (Small)

### Shape:

- Good for many applications (GDT, Inductors, push-pulls)
- Good balance between small footprint and low profile



### Manufacturability:

- Good, highly automatable.

### Winding:

- Small winding volume



### EMI:

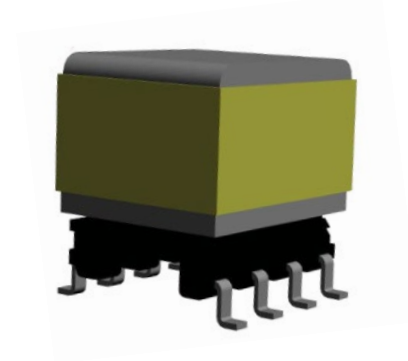
- The core shape provides very good EMI Shielding

### Power Density:

- Very Good

### Pick and Place:

- Excellent for pick and place



# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

## ER Package (Small)

### Shape:

- Very low profile



### Manufacturability:

- Not so easy to automate.



### Winding:

- Limited bobbin options and difficult termination.

### EMI:

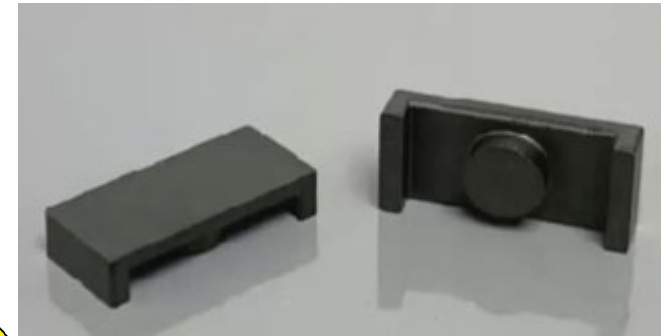
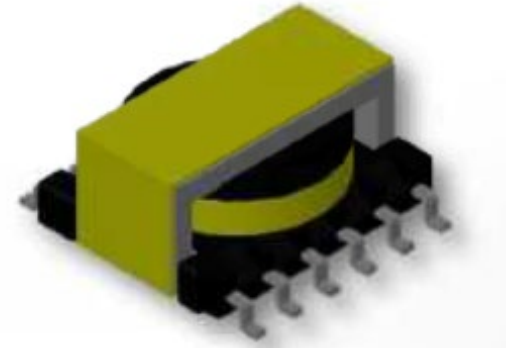
- The core shape provides some EMI self Shielding

### Power Density:

- Average

### Pick and Place:

- Excellent for pick and place due to the flat smooth top of the Package



# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

## RM Package (Small / Medium)

### Shape:

- Small footprint and low profile
- Frequently used for inductors



### Manufacturability:

- Not so easy to automate



### Winding:

- Many pins can be used
- Big winding area

### EMI:

- Provide some EMI protection

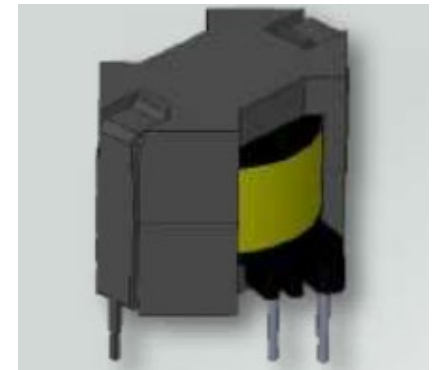
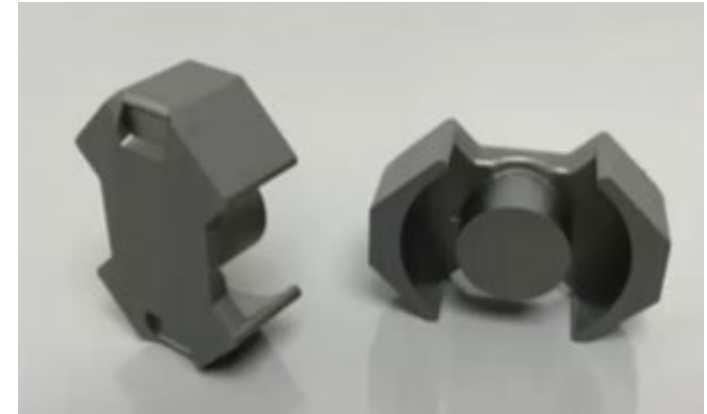
### Power Density:

- Very good / good fit in the PCB



### Pick and Place:

- Available, but THT versions are more common.



# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

## EE Package (Medium)

### Shape:

- Good balance between small footprint and low profile



### Manufacturability:

- Good, highly automatable

### Winding:

- Good choice if many windings
- Great availability of different bobbin



### EMI:

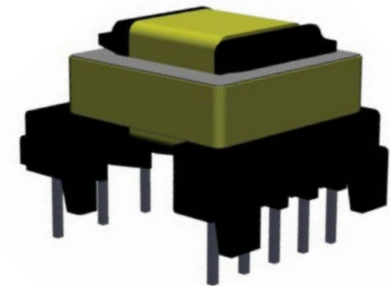
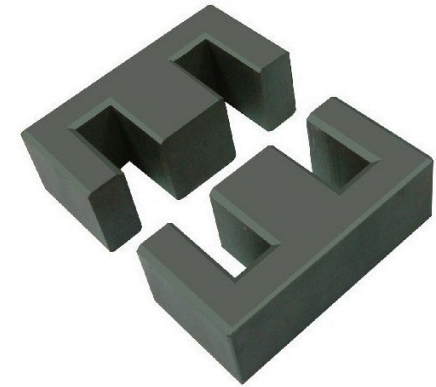
- Doesn't provide any shielding

### Power Density:

- Average

### Pick and Place:

- Not suitable (A cap can be added)



# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

## EFD Package (Medium)

### Shape:

- Very low profile / Large footprint



### Manufacturability:

- Medium / good

### Winding:

- Limited winding volume



### EMI:

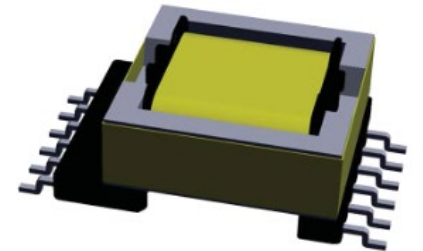
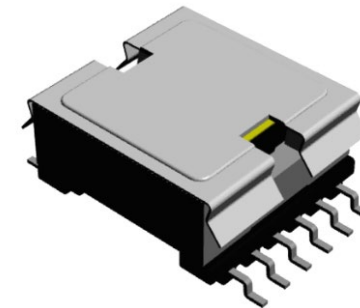
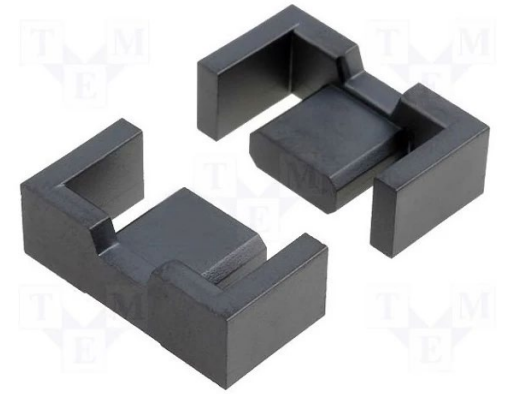
- The core shape provides some EMI self shielding

### Power Density:

- Average

### Pick and Place:

- Excellent for pick and place when the design adds a metal clip



# HOW DO WE CHOOSE THE BEST PACKAGE FOR OUR MAGNETICS

## ETD Package (Large)

### Shape:

- Good for many applications (Half Bridges, LLCs,...)
- Good balance between small footprint and low profile



### Manufacturability:

- Medium

### Winding:

- Many terminals (some up to 20 pins)
- Good choice for transformers with many windings

### EMI:

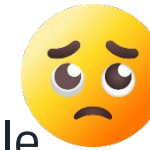
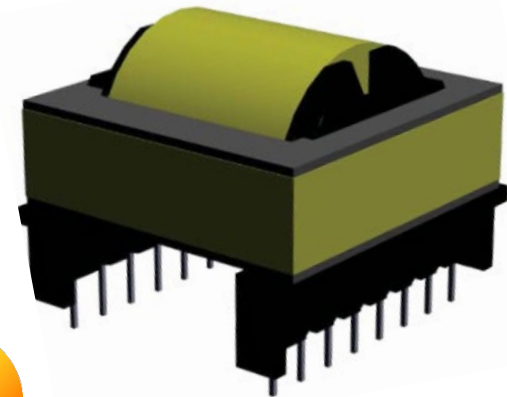
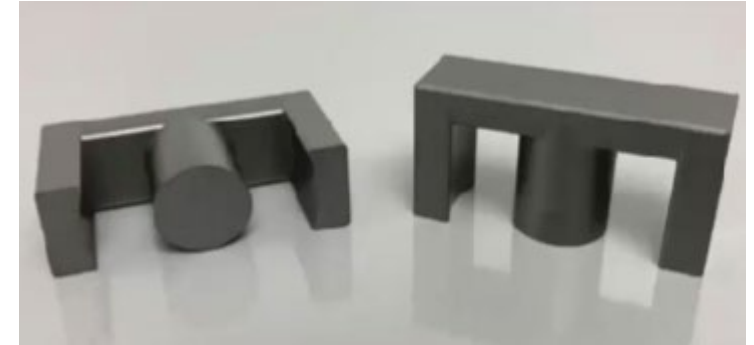
- Doesn't provide much EMI protection

### Power Density:

- Average
- The design is suitable for high power applications

### Pick and Place:

- Not suitable for pick and place and only THT versions are available



## SUMMARY

Strong points of each packages

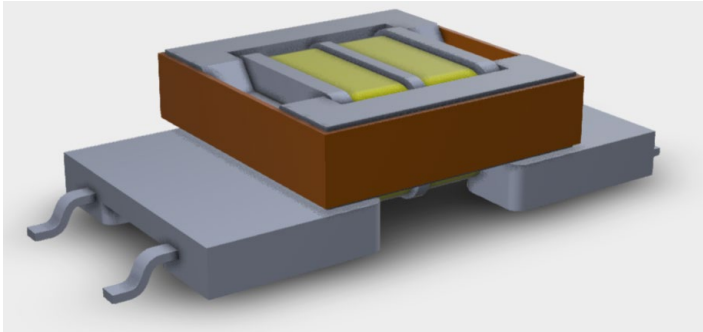
|                | EE                                                                                | EFD                                                                                | EP                                                                                  | ETD                                                                                 | PQ                                                                                  | RM                                                                                  |
|----------------|-----------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| Cost           |  |                                                                                    |   |  |  |                                                                                     |
| Winding        |  |                                                                                    |                                                                                     |  |  |  |
| EMIs           |  |                                                                                    |   |                                                                                     |                                                                                     |  |
| Power Density  |                                                                                   |   |   |                                                                                     |                                                                                     |  |
| Pick and place |                                                                                   |  |  |                                                                                     |                                                                                     |                                                                                     |

**The Perfect package does not exist!**

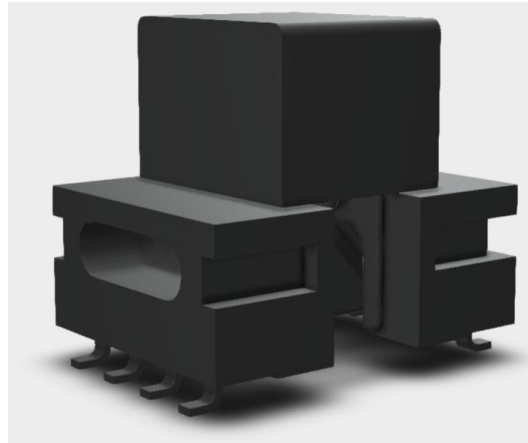
But **WE** can help choosing the best package for you!

## NO PACKAGE THAT SUITS YOU?

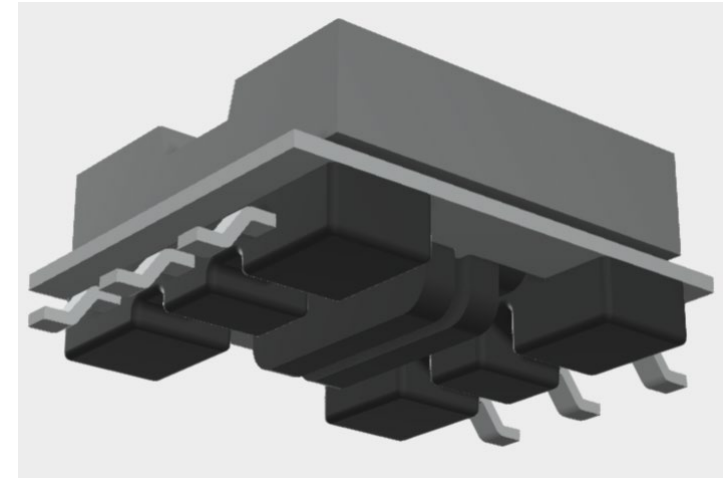
Let's go custom!



EFD10 (070-8133) – 2 Sections  
Extended Rails - Low profile



EP7 (070-8044)  
High creepage – High  
volume



EFD10 (070-7385)  
Solid insulation – High volume

Make your wish 🪄 👷 ⚙️ **WE** can make it happen!

# THANK YOU!



Credits: Hasbro