what is right with magnetics?

Alexander Gerfer
CTO Würth Elektronik eiSos Group
nothing!
nothing?
magnetics...

... confusion all around
ferrite is not ferrite!

Maganese-Zink (MnZn) group

Nickel-Zink (NiZn) group
ferrite is not ferrite!

Maganese-Zink (MnZn) group
ferrite is not ferrite!

good basic information is available
the headache ....

Relative permeability is a:

\[ B = \mu_0 \cdot \mu_r \cdot H \]

material-
frequency-
temperature-
current-
pressure-
dependent parameter
good core materials are available
good core materials are available
Properties of the magnetic materials
- dielectric constant and conductivity

**Measurement setup**

WayneKerr 6550B interface

BNC connectors

Compression force control

Tensometer

**Electrode shielding for reduced stray capacitance at the edge of the electrodes**

**Electrode shape and size adapted to the tested Sample size and shape**
and how do these parameters translate into the **physical core**?

\[
\begin{align*}
\mu &= \mu' - j\mu'' \\
\hat{B} &= \mu \hat{H} \\
p_m(t) &= H(t) \cdot \frac{\partial B(t)}{\partial t} \\
\bar{p}_m &= \frac{1}{T} \int_0^T p_m(t) \, dt \\
\bar{p}_m &= \frac{1}{2} \omega \mu'' \hat{H}^2 \\
\varepsilon &= \varepsilon' - j\varepsilon'' \\
\hat{D} &= \varepsilon \hat{E} \\
p_d(t) &= E(t) \cdot \frac{\partial D(t)}{\partial t} \\
\bar{p}_d &= \frac{1}{T} \int_0^T p_d(t) \, dt \\
\bar{p}_d &= \frac{1}{2} \omega \varepsilon'' \hat{E}^2 \\
\kappa &= \lambda \\
\hat{J} &= \kappa \hat{E} \\
p_e(t) &= E(t) \cdot J(t) \\
\bar{p}_e &= \frac{1}{T} \int_0^T p_e(t) \, dt \\
\bar{p}_e &= \frac{1}{2} \kappa \hat{E}^2 \\
\bar{p}_v &= \bar{p}_m + \bar{p}_d + \bar{p}_e
\end{align*}
\]

Source: Messtechnische Bestimmung und Simulation der Kernverluste in weichmagnetischen Materialien, Alexander Stadler, 2009
magnetics is not magnetics

customized

standardized
billions of power supplies per year...

... are all wrong?
standardization took place…

… one will fit for sure!
miniaturization took place
are those the best core design for GaN/ SiC ?

<table>
<thead>
<tr>
<th>EE Style Bobbins</th>
<th>EFD Style Bobbins</th>
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</thead>
<tbody>
<tr>
<td>EP Style Bobbins</td>
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<td>RM Style Bobbins</td>
<td>EPQ Style Bobbins</td>
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</table>
need for new design thinking

source: APEC2018; presentation
ROMPOWER, Ionel Jitaru
12V out @ 83A / 1kW
need for new design thinking
need for new design thinking

Example usage of Anhysteretic BH data for designs

Input data to Multi-Objective Genetic Algorithm Design Optimization

- NETL has the ability to engineer permeability using strain-annaeling.
- This capability is integrated into **Multi-objective Genetic Algorithm** based optimization package for “flux-smoothing” where a more uniform flux distribution is present within the core.

![Permeability data](chart)

Flux Density Distribution

- **Constant Perm Core**
  - \(\mu_r > 38.3\)

- **Graded Perm Core**
  - \(\mu_r = 27.8 \rightarrow 44.5\)

Better core utilization via to more uniform core temperature due to flux-smoothing permeability engineering
need for new design thinking

In radio communications, an evolved antenna is an antenna designed fully or substantially by an automatic computer design program that uses an evolutionary algorithm that mimics Darwinian evolution.

This sophisticated procedure has been used in recent years to design a few antennas for mission-critical applications involving stringent, conflicting, or unusual design requirements, such as unusual radiation patterns, for which none of the many existing antenna types are adequate.

The 2006 NASA ST5 spacecraft antenna. This complicated shape was found by an evolutionary computer design program to create the best radiation pattern.
how would AI design magnetics for GaN/ SiC ?
what is right with magnetics?

Alexander Gerfer
CTO Würth Elektronik eiSos Group
a lot!

Alexander Gerfer
CTO Würth Elektronik eiSos Group
backup
magnetics are now in focus

old technology of switches

<table>
<thead>
<tr>
<th>Component</th>
<th>Power Dissipation (watts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>primary switches</td>
<td>5.84</td>
</tr>
<tr>
<td>secondary switches (SRs)</td>
<td>5.29</td>
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<tr>
<td>transformer</td>
<td>3.68</td>
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<tr>
<td>output choke</td>
<td>0.33</td>
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</table>

Source: APEC2018; Presentation ROMPOWER; Ionel Jitaru
magnetics are now in focus

**GaN/ SiC switches**

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<tr>
<th>Component</th>
<th>Power Dissipation (watts)</th>
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<tbody>
<tr>
<td>Primary switches</td>
<td>2.38</td>
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<tr>
<td>Secondary switches</td>
<td>3.12</td>
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<tr>
<td>Transformer</td>
<td>1.9</td>
</tr>
<tr>
<td>Output choke</td>
<td>0.33</td>
</tr>
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</table>

Source: APEC2018; Presentation ROMPOWER; Ionel Jitaru