



The Multinational Power Electronics Association



PSMA Magnetics Committee Meeting

February 28th 2024

Ed Herbert, George Slama, Matt Wilkowski
Committee Chairs



PSMA is a not-for-profit organization and a CO-SPONSOR OF APEC



PSMA Magnetics Committee Meeting Agenda

February 28, 2024

- Introductions
- Magnetics Committee Report for March BOD
- 2024 Workshop Review
- 2024 Workshop Planning
- 2024 Industry Session Planning
- Power Technology Roadmap
- Special Projects
 - In Process
 - Core Loss Database
 - Electrical parameters of magnetic materials
 - Pending
 - Steinmetz Like Approximation
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 - Propagation in magnetic materials
 - Current driven core loss testing
 - Spice model
- Brief over of new magnetic material from HIMET Materials
- Magnetics Committee Forum on PSMA Website
- Next Meeting



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Overall vision 2020-2025 - Sustenance & smart growth



Pillar	Progress to date	Outlook & Suggestions
Magnetics @ High Frequency Workshop	<ul style="list-style-type: none">• 2024 theme...<ul style="list-style-type: none">• AM - Design and Optimization of Magnetics for Different Applications• PM – Special issues as thermal, partial discharge, insulation, etc.• Attendees: 132	<ul style="list-style-type: none">• 2025<ul style="list-style-type: none">• would be 10th annual workshop• Next gen of organizers
APEC Industry Session	<ul style="list-style-type: none">• 2024 theme<ul style="list-style-type: none">• Modelling and simulation of magnetics – closing the loop• Seven confirmed presenters	<ul style="list-style-type: none">• 2025<ul style="list-style-type: none">• Next gen of organizers

Overall vision 2020-2025 - Sustenance & smart growth



Pillar	Progress to date	Outlook & Suggestions
Webinars	<ul style="list-style-type: none">Pre 2022 – provided training webinars on various subjects	<ul style="list-style-type: none">Address a need for training webinars during the fall timeframe to help promote the workshop and industry session tied to APEC in spring?<ul style="list-style-type: none">These may be competing with other industry webinars that are prevalent in the fall.Short 15-minute videos on demand for specific topics accessible from magnetics forum
Roadmap	<ul style="list-style-type: none">2023 Fall – one presenter<ul style="list-style-type: none">Core Loss Mechanisms – Tyndall – Ranajit Sai	<ul style="list-style-type: none">2024 – identified three presenters<ul style="list-style-type: none">Wafer Level Magnetics – Fraunhofer – Florian ZieglerTech Roadmap for Nanocrystalline Cores – CBMM – Bharadwaj Reddy AndapallyHigh power charging – Utah State University – Reebal Nimri

Overall vision 2020-2025 - Sustenance & smart growth

Pillar	Progress to date	Outlook & Suggestions
Special Projects	<ul style="list-style-type: none">• Active<ul style="list-style-type: none">• Core Loss Database• Electrical parameters of ferrite materials• Future considerations<ul style="list-style-type: none">• Study propagation in magnetic materials• Spice model BH loop• Current driven core loss testing• Steinmetz like approximation	<ul style="list-style-type: none">• Core Loss Data Base:<ul style="list-style-type: none">• Project nomination to be presented at BOD on Feb 26 2024• Request: \$35K first year• \$5K maintenance per year ongoing• Sponsorships to cover cost of yearly fees• Electrical parameters of ferrites<ul style="list-style-type: none">• Nomination form approved for Nov BOD meeting• Estimated budget: \$12K• Preliminary report under review by magnetics committee
Collaboration	<ul style="list-style-type: none">• 2022 Previous collaborations outside of PSMA – stalled has become more of an individual effort rather a committee effort for design engineer training webinar/presentations	<ul style="list-style-type: none">• Coordinate magnetics workshop with capacitors committee.• Support Manufacturing and Packaging committee – Power Technology Report for embedded and integrated magnetics

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Power Magnetics at High Frequency Workshop

Logistics – Agenda - Scope

- Logistics
 - Venue:
 - APEC 2024
 - Long Beach CA
 - Attendance
 - 132
 - 27% Research 73% Industry
 - 68% NA, 22% Europe, 9% Asia Pacific, 1% SA
 - 18 Countries

- Agenda

Time	Event
7:00 AM - 8:00 AM	Breakfast
8:00 AM - 8:05 AM	Opening Remarks
8:05 AM - 8:45 AM	Keynote Presentation: Opportunities for New Magnetics Designs to Address Market-Driven Technology Trends in Automotive Applications
8:45 AM - 9:40 AM	Technical Session - Design and Optimization of Magnetics for Different Applications Part I
9:40 AM - 10:00 AM	Break
10:00 AM - 12:00 Noon	Technical Session - Design and Optimization of Magnetics for Different Applications Part II
12:00 Noon - 2:00 PM	Technology Demonstration and Posters Session
2:00 PM - 2:50 PM	Keynote Presentation: Thermal, Scaling and Dielectric Issues in Magnetics Design
2:50 PM - 3:40 PM	Technical Session - Thermal Design and Other Special Issues: Partial Discharge, Insulation, etc. - Part I
3:40 PM - 4:00 PM	Break
4:00 PM - 4:45 PM	Technical Session - Thermal Design and Other Special Issues: Partial Discharge, Insulation, etc. - Part II
4:45 PM - 5:00 PM	Closing Remarks - Best of the Best
5:00 PM - 6:00 PM	Networking Session

- Scope
 - This day-long event continued the workshop series' focus on identifying the latest improvements in magnetic materials, coil (winding) design, construction and fabrication, evaluation and characterization techniques and modelling and simulation tools to target the technical expectations and requirements of higher application frequencies while addressing two specific issues of interest: measurement and reporting of data to improve modelling of ac power loss measurements and the impacts of fringing effects on power magnetics performance. The target audience for this workshop is anyone working to achieve higher power densities, low profile aspect ratio, higher efficiencies and improved thermal performance.

Power Magnetics at High Frequency Workshop (Participation)

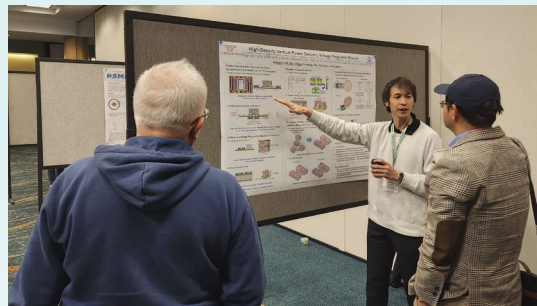
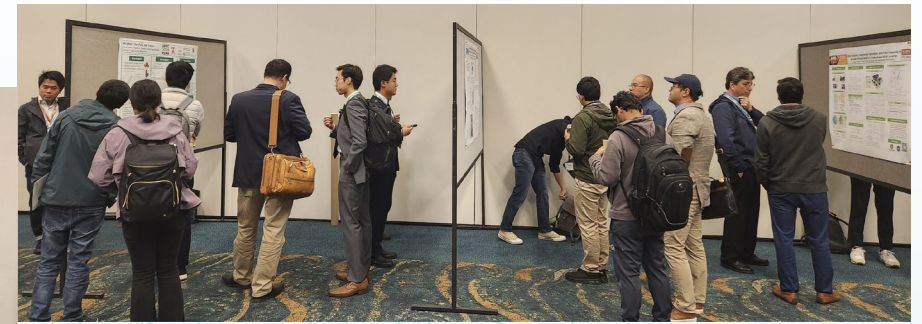
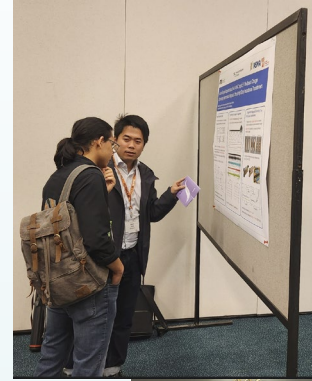
- Attendance
 - Total: 132
 - By Sector
 - 73% Industry, 27% Research
 - By Global Region
 - 68% NA, 22% Europe, 9% Asia Pacific, 1% SA
 - 18 Countries
- Participation
 - Highly interactive panel discussions
 - Synergy between lectures and demos
 - Focused questions
 - Technology demonstrations combined with lunch
 - Attendance continues to grow post Covid



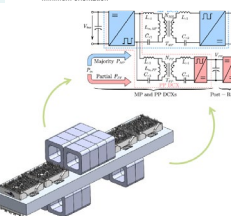
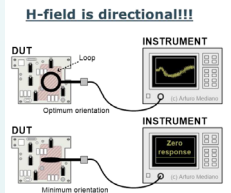
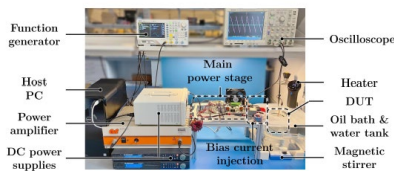
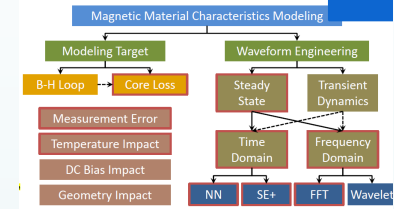
Power Magnetics at High Frequency Workshop (What's Next)

What's Next

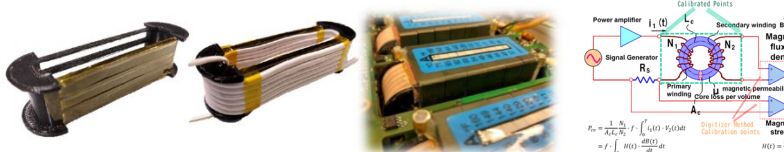
- Preliminary Survey Results (82 responses)
 - Overall Rating: 61% response rate
 - 36% Excellent, 46% Very Good, 17% Good
 - Value
 - 49% Excellent, 40% Good, 11% Average
 - Skill of the presenters
 - 58% Superior, 33% Above Average 9% Average
 - Recommend workshop to a colleague
 - 83% Yes, 15% maybe, 2% No
 - First Time attendees 60%
 - Plan to attend next year 63% Yes 35% Maybe
 - General topics for next workshop based on survey
 - Thermal Design - Power Loss Density – Thermal Aging
 - Core Loss testing, modelling & specification
 - Integrated Magnetics



Power Magnetics at High Frequency Workshop (Depth & Relevance of Topics)



High-frequency PWM PD Test Platform



AC Switching Inductor – Material Evaluation

- AC resonant inductors are crucial in modern resonant converters (like LLC)
- AC Inductor (Resonant converter)
- Low Core Loss
- High Q

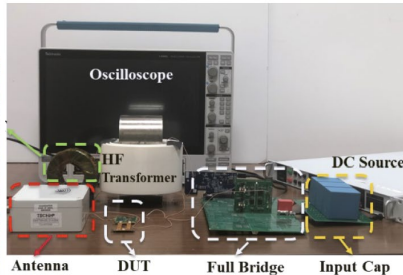
$$P_{total} = LI^2_{pk} \left(\mu_0 \mu_{r,eq} k_{core} + \frac{\rho l_c M L T}{2 k_{eff} W_{eff} A_c \mu_0 \mu_{r,eq}} \right)$$

Low core loss is important, but only part of the equation

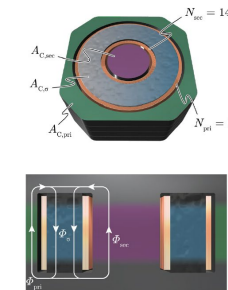
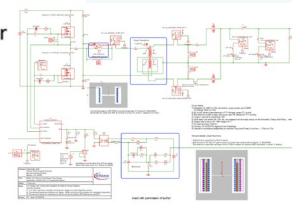
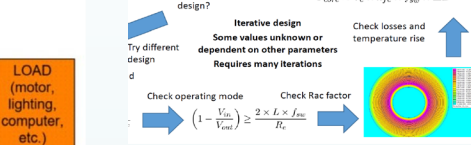
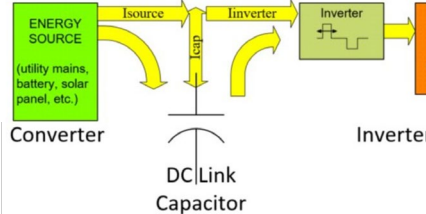
Relative effective permeability important. The higher the effective permeability, the higher the core losses but lower copper losses. There is an optimum:

$$\mu_{r,eff,opt} = \frac{1}{\mu_0} \sqrt{\frac{\rho l_c (MLT)}{2 k_{eff} W_{eff} A_c k_{core}}}$$

MICROMETALS
POWDER CORE SOLUTIONS



Approximate Ripple Current:
 $I^2_{cap(rms)} \approx I^2_{source(rms)} + I^2_{inverter(rms)}$

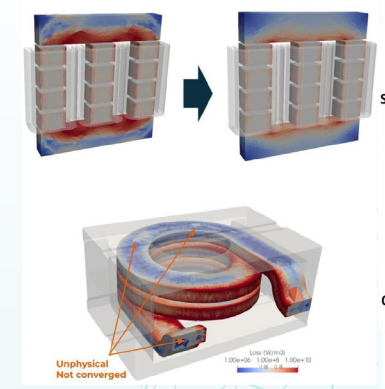
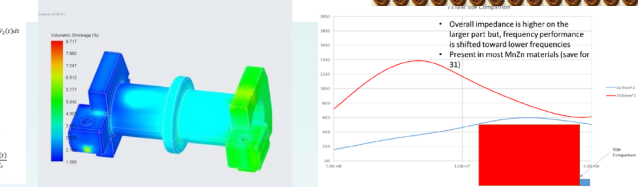


Transformer Dimensions and winding arrangement of the foil winding transformer

Example: 1 full-size L vs. 100 small Ls

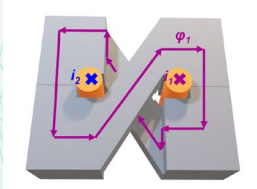
- 100 small inductors can be:
 - In series, each L'=L/100.
 - In parallel, each 1/100 full current, but 100X L value.
 - Network of 10 in series/10 in parallel, same L value.
 - In each, energy storage and VA are reduced by 100X
- With our assumptions, these options are equivalent.
- Adjust N to obtain value needed; doesn't change loss or power handling (VA).

Can they be tiny?

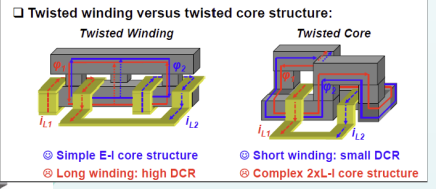
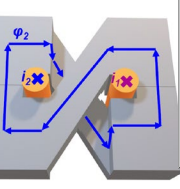


Unphysical Not converged

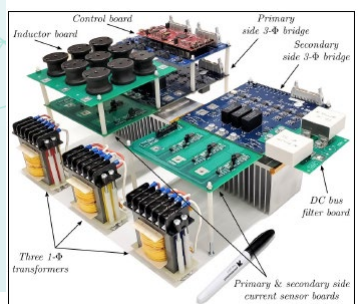
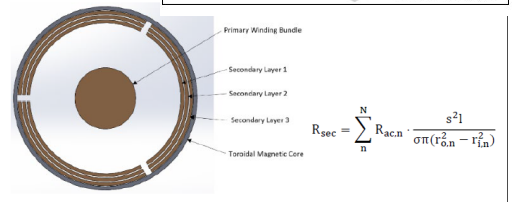
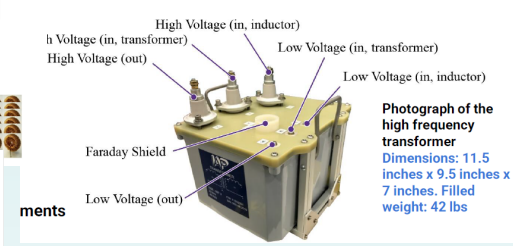
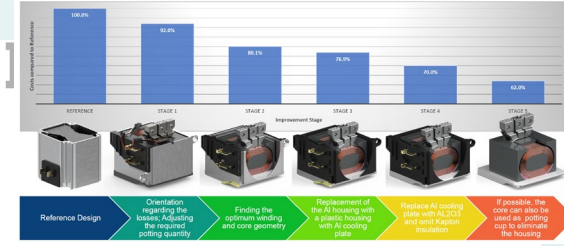
Flux from I_1



Flux from I_2



The proposed twisted core structure achieved negative coupling with the shortest straight winding path and same current direction



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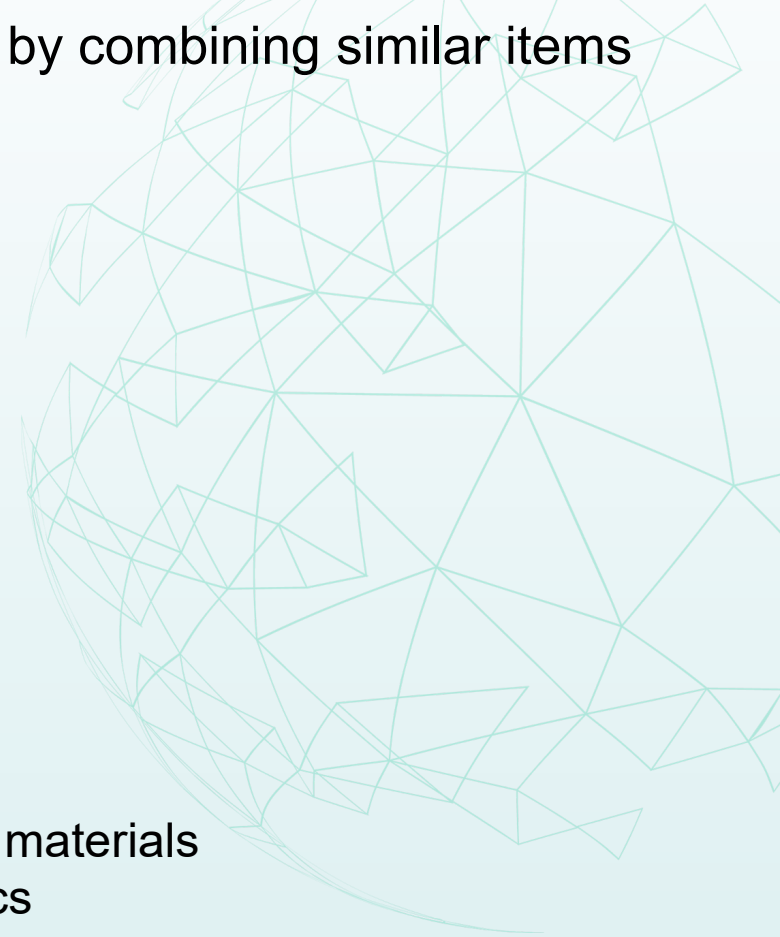


Question 9: Please suggest topics for the magnetics workshop to concentrate on next year.

Pre-sort

Pare down original list of 65 items to 15 items by combining similar items

1. Magnetic integration
2. Best practices on testing
3. AC winding loss modeling
4. Core testing
5. Database sharing
6. Core modeling
7. AI for modeling and design
8. Manufacturing of magnetics, DFM
9. Planar magnetics
10. Insulation materials and failures
11. Medium voltage magnetics
12. New magnetic materials
13. Electroplated, thin film, 3D printed magnetic materials
14. Wireless, EV, coupled, multi phase magnetics
15. Cooling concepts




Sponsored by:



PSMA Magnetics Committee Meeting Agenda Workshop Planning Notes

February 28, 2024

- Integrated Magnetics
 - Physical Integration
 - Heterogeneous Integration
 - 2.5D Vs 3D
 - Thermal Limitations
 - Assembly methods
 - Power System in Package
 - Embedded magnetics
 - PCB windings about a magnetic core
 - Wafer level magnetics
 - Sputtered
 - Electroplated
 - Electrical Characteristic Integration
 - LLC
 - Coupled Inductors
 - TLVR



Integration
has different meaning
for different audiences

PSMA Magnetics Committee Meeting Agenda Workshop Planning Notes

February 28, 2024

- Additional discussions
 - Start to finish to manufacture a magnetic components
 - Materials
 - Conductors
 - Insulation
 - Core Materials
 - Assembly
 - Testing
 - Qualification
 - Reliability
 - Application/Environment Considerations
 - Cooling
 - » Conduction
 - » Forced Air
 - Special Consideration
 - » Aerospace
 - » Automotive
 - Other

Could be industry session
Reference SST discussion
on industry session slide

PSMA Magnetics Committee Meeting Agenda Workshop Planning Notes

February 28, 2024

- Additional discussions
 - Core Loss Testing & Modelling can be one session
 - Impact of machine learning to predict core loss
 - AI for overall design?



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PSMA Magnetics Committee Meeting Agenda - Industry Session Planning Notes

February 28, 2024

- All aspects of fabricating a Solid-State Transformer (SST)
 - Conductor design
 - Insulation/Isolation Issues
 - AC Power Loss
 - Magnetic Core materials
 - Thermal Design
 - Environmental Design
 - Capacitance
 - Coupling and Leakage Inductance
 - Other?
 - Are there seven specific topics to fill an industry session
 - Or should we consider four topics to fill the afternoon of the magnetics workshop
- Focus on the transformer of Solid-State Transformer
 - Too many APEC and ECCE session on SST focus on topology rather than the transformer



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2022/2023/2024 PSMA PTR Webinar Series

Potential Contributions from the Magnetism Committee

- Tyndall – Ranajit Sai
 - Core Loss Mechanisms
 - Presentation delivered November 30 ✓
- Utah State University – Reebal Nimri
 - High Power (1 MW) Charging
 - 2024 Q2/Q3
 - Confirmed 8/16/23
- Fraunhofer – Florian Ziegler
 - PowderMEMS – a novel technology for fabrication of functionalized MEMS structures
 - Spring 2024
 - Confirmed 1/16/24
- CBMM - Bharadwaj Reddy Andapally
 - Technology Roadmap for Nanocrystalline Cores
 - Spring 2024
 - Confirmed: 9/1/23 – follow up sent December 15



Potential Source of Additional Presentations
Intermag Japan
Presentations
Measurement Techniques
New Materials

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PSMA Magnetism Committee Meeting Agenda – Special Projects

February 28, 2024

- Electrical parameters of magnetic materials
 - Proposal approved during PSMA BOD meeting on November 17
 - Preliminary results shared with PSMA Magnetism Committee during December 18 meeting
 - Draft report distributed by e-mail to attendees of January 24 PSMA Magnetism committee meeting
 - Final report to be discussed for approval to be placed on a tab on the Magnetism Forum during meeting on February 28

Discussion Decisions

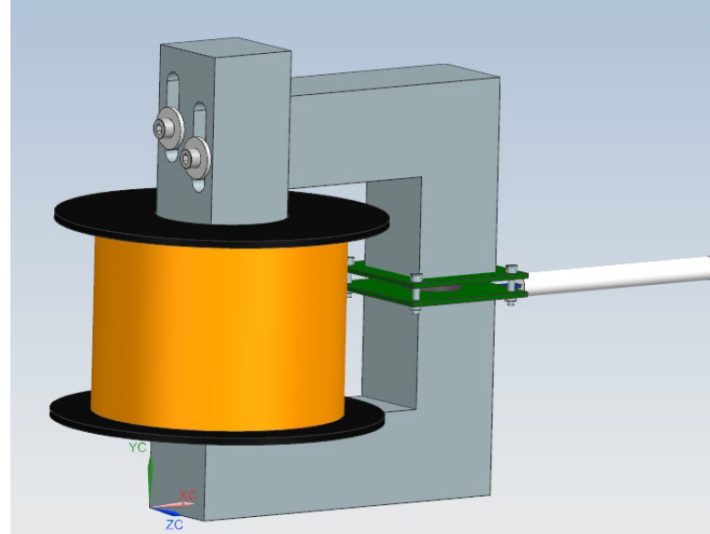
- Draft dated January 22 2024 is ready to placed in the Special projects Tab on Magnetism Forum
 - Confirmed by Ed Herbert and Jonas Muhlethaler
 - This report should be behind a members only firewall
 - Reference Ed Herbert e-mail of February 25, 2024
- Maintain Core Loss Studies as a Separate Tab
- Create a new Special Projects tab for all this and all future special projects
- In the future Core Loss Data Base may be a separate tab from Core Loss Studies

PSMA Magnetics Committee Meeting Agenda – Special Projects

February 28, 2024

Lucerne University of Applied Sciences and Arts

Lucerne School of Engineering and Architecture



Characterization of Core Material

Author: Frédéric Mathieu

Supervisor: Prof. Dr. Jonas Mühlethaler

Expert: Dr. Severin Nowak

Industrial partner: Power Sources Manufactures Association (PSMA)

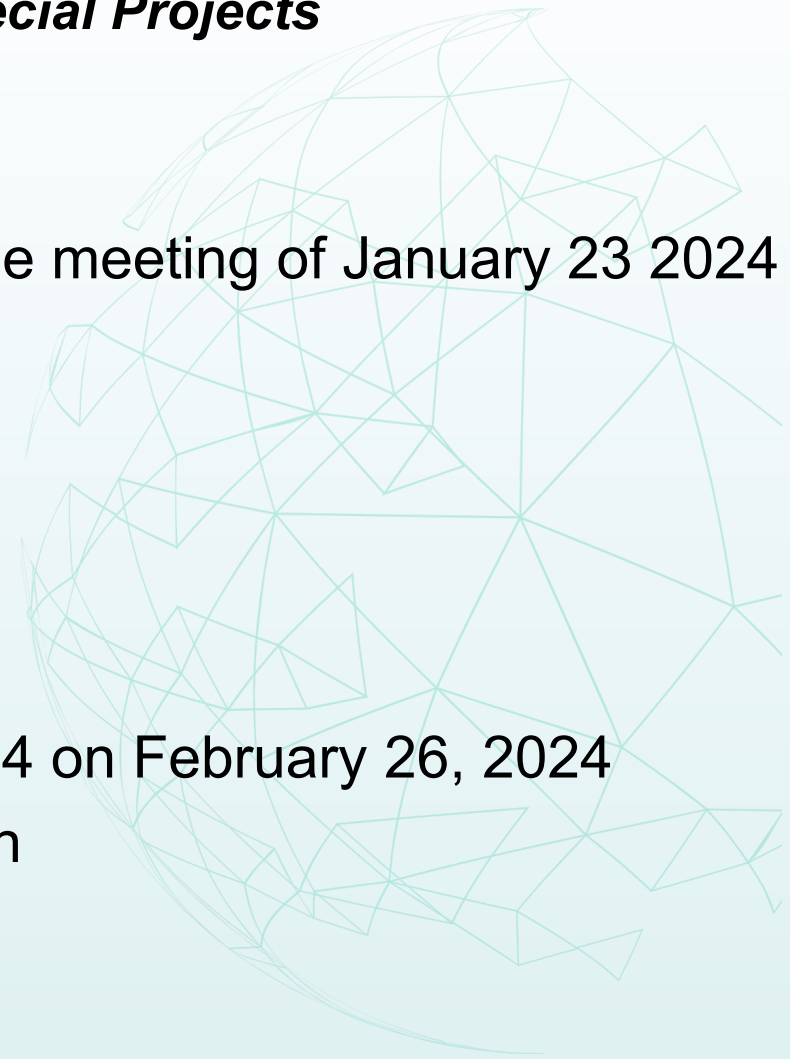
January 22, 2024

Confidentiality level: Public

PSMA Magnetism Committee Meeting Agenda – Special Projects

February 28, 2024

- Core Loss Database
 - E-mail ballot after PSMA Magnetism Committee meeting of January 23 2024
 - Ballots sent:13
 - Ballots Returned:11
 - Return Rate: 85%
 - Approve Ballots: 11
 - Disapprove Ballots: 0
 - Approval Rate: 100%
 - Special project proposal to BOD at APEC 2024 on February 26, 2024
 - BOD decision due next BOD meeting in March



PSMA Magnetism Committee Meeting Agenda – Special Projects

February 28, 2024

- **Proposal Presented to PSMA BOD on February 26 2024**

How will this Project support the mission of PSMA?

This project will advance the gathering and sharing of core loss data of all types of magnetic core materials among members and the power supply community as a whole. It will also drive traffic to the PSMA website to enlarge its presence.

Who will benefit from this project? What will be the benefits?

Designers of magnetic components and developers of models for analysis of magnetic components. It will be a source of data for modeling based on artificial intelligence (AI)

What will be the output of the project? (report, workshop, award, etc.)

Website, database, online interactive charts, possible online community

What is the budget for this project?

Not to exceed \$35,000. Estimated ongoing cost \$5000/year

PSMA Magnetics Committee Meeting Agenda – Special Projects

February 28, 2024

- Proposal Presented to PSMA BOD on February 26 2024

Please provide a breakdown for the expected expenses.

Description	Expected Cost
Database setup and programming	\$7,000
Website Backend programming	\$10,000
Website Frontend programming	\$10,000
Hosting Server, Database hosting	\$3,000
Contingency*	\$5,000

*Software programming estimates continue to be very imprecise.

Project Milestone Targets

Milestone	Target Date
Final specification document	May 1, 2024
RFQs and selection of vendor	June 1, 2024
Development	Nov 1, 2024
Live	Dec 31, 2024

PSMA Magnetism Committee Meeting Agenda – Special Projects February 28, 2024

- Proposal Presented to PSMA BOD on February 26 2024

Measure of success for this project:

Since it is a website we can track visits, downloads and uploads to develop several KPIs. Initial success would be increasing number of visitors, then the number of that use data online (charts), then those that download data and finally contributors who upload data.

Since there is a small ongoing maintenance cost, the board needs to consider, though not approve at this time, that the site may need three to five years to establish itself. Like the other PSMA databases, an annual review and approval process would be put in place.

PSMA Magnetics Committee Meeting Agenda – Special Projects

February 28, 2024

- **Proposal Presented to PSMA BOD on February 26 2024**

Background:

This proposed project is among several contemplated by the magnetics committee.

A consistent theme at APEC over the past decade or more has been the complaints about the lack to magnetic core loss data available for rectangular voltage excitation, varying duty cycles, high frequency and with DC bias. In the last several of years, the resurgence of artificial intelligence (AI), now using neural networks has been applied to the design of magnetic components and in particular the estimation of core losses. The application takes in existing core loss data under one condition (i.e. Manufacturers' sine wave data) and tries to predict the losses at a different condition (i.e. power supplies with rectangular voltage excitation at different frequencies and duty cycles). To accomplish this, there must be a large data set of measurements under many conditions to train the AI model. Additionally, this data needs to be in a digital format for use with computer programming. Traditionally, core loss data is presented in printed charts or as parameters for equations that cover only a small range of conditions. Both need to be manually translated into a digital format. Furthermore, there is no central repository that includes data from multiple core manufacturers (more than 30 for ferrite alone). To compare materials from different manufacturers; the designer must visit each website, find, gather and download the data of interest and compare it to other manufacturers in his own way. A very time-consuming process. The data may not even be directly comparable due to different test conditions. The advent of GaN and SiC semiconductor devices is slowly pushing the operating frequencies of power supplies higher where the data is more limited.

PSMA Magnetics Committee Meeting Agenda – Special Projects

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- Proposal Presented to PSMA BOD on February 26 2024

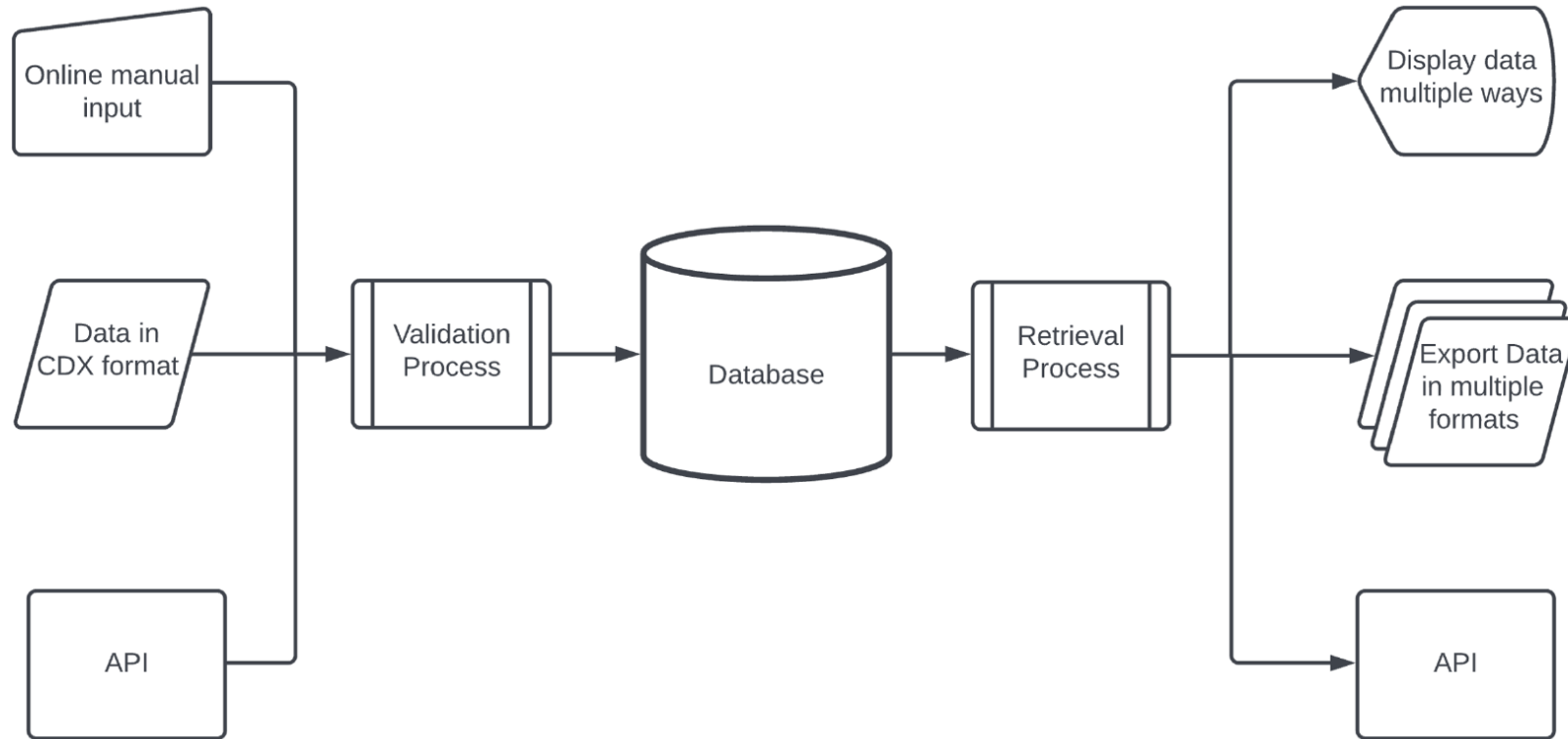


Figure 1: Schematic overview of inputs on the left and outputs on the right of the database.

PSMA Magnetism Committee Meeting Agenda – Special Projects

February 28, 2024

- **Proposal Presented to PSMA BOD on February 26 2024**

The project proposes to address this situation by

- 1) Creating an open-source portal where users of core loss data can get and contribute data as described below.
- 2) Creating a database of core loss data, initially from existing sources but targeting the community (industry and academia) to contribute. Data from the database would be freely accessible for downloading and for uploading contributed data to registered users. No fee.
- 3) Creating a website to interact with, support and access the database.
- 4) Providing a charting capability of core data online through the website. The user can search from through all the data in the database to visualize and compare materials under whatever conditions they need. For example, data from multiple vendors on the same chart.
- 5) Provide and promote a standard format for the data.
- 6) Provide export formats for large or small amounts of data.
- 7) Provide direct application program interface (API) access for magnetism design computer programs to get data.
- 8) Provide documentation to the user to setup and do their own core loss testing.
- 9) Provide a Q&A, discussion or help area for users regarding the website and core loss testing.

PSMA Magnetism Committee Meeting Agenda – Special Projects

February 28, 2024

- Proposal Presented to PSMA BOD on February 26 2024

PSMA is ideally suited to sponsor and benefit from this project by

- 1) By being a neutral party. It is neither an academic institution or a commercial company. Academic institutions are driven by funding and self interest in their chosen fields so they cannot be depended upon as a reliable long term sponsor though they will make excellent contributors. If a commercial core manufacturer or magnetic manufacturer was the sponsor it would not be trusted as unbiased and again subject to budgets. Again, they make excellent contributors.
- 2) PSMA is already sponsors two databases as source of information to members and has a structure to do so.
- 3) PSMA can provide the administration framework.
- 4) PSMA is well known and has an established web presence.
- 5) A key part of the PSMA is to sponsor events and special projects for the benefit of its members.
- 6) Raise awareness and status of PSMA as an innovator and leader in meeting the needs of its members.

PSMA Magnetism Committee Meeting Agenda – Special Projects February 28, 2024

- Proposal Presented to PSMA BOD on February 26 2024



Four types of quality are:

- a) Unknown – Not allowed.
- b) Quantified – Based on tolerances of measuring equipment and setup – can be calculated automatically from user inputs. Minimum requirement.
- c) Calibrated – Based on a defined procedure and a calibration kit of pretested cores to establish known limits.
- d) Certified – Based on comparison to ‘golden cores’ – cores that have been tested on multiple systems and calorimetrically to have a high confidence of accuracy. Must be physically stored and shipped around.

PSMA Magnetism Committee Meeting Agenda – Special Projects

February 28, 2024

- **Proposal Presented to PSMA BOD on February 26 2024**

A second important aspect of the project is to define and promote a data exchange format. Currently data is often exchanged in excel cvs format in some unique format that works for the creator of the data. In order for data to be universally exchanged without using proprietary formats for each source, a universal format designed for computer usage needs to be developed. A universal format accessing a universal database makes using the data in computer programs simple and straight forward encouraging its use. The subcommittee is working on a format using the JSON data format. This is a human readable format that allows a high degree of organization within the file. It also contains the critical feature of expandability without breaking its use by older programs. An example is a program setup to read a cvs file. If a new line or column is added to the file, the computer program must be modified to read it properly even if the new information is not needed. With JSON file, the new information is simply ignored. This allows adding more information as the need arises. Thus, part of the project to create and promote industry standardization in cooperation with the other entities like the IEEE PELS Electronic Transformer Technical Committee (ETTC) which can create an official standard.

The project addresses a long-standing need in the power supply community, recognizes the increased use of digital data for design and simulation and puts the PSMA into a position of leadership in addressing it.

PSMA Magnetics Committee Meeting Agenda

February 28, 2024

- Introductions
- Magnetics Committee Report for March BOD
- 2024 Workshop Review
- 2024 Workshop Planning
- 2024 Industry Session Planning
- Power Technology Roadmap
- Special Projects
 - In Process
 - Core Loss Database
 - Electrical parameters of magnetic materials
 - Pending
 - Steinmetz Like Approximation
 - Electrical parameters of magnetic materials
 - Propagation in magnetic materials
 - Current driven core loss testing
 - Spice model
- Brief over of new magnetic material from HIMET Materials
- **Magnetics Committee Forum on PSMA Website**
- Next Meeting



PSMA Magnetics Committee – Brief Overview of HIMET Materials LLC

February 28, 2024

- URL: https://himet-materials.com/?gclid=EAlaIQobChMIzp-UhZfbhAMVNjfUAR1dEw3REAAAYASAAEgKYW_D_BwE



The screenshot shows the homepage of HIMET Materials LLC. The browser address bar displays the URL. A blue navigation bar at the top contains the company's tagline. Below this is the HIMET Materials LLC logo, which is a triangle with the company name inside. To the right of the logo is a horizontal menu with links to Home, Catalog, Sputtering & PLD Targets, Evaporation Materials, Single Crystal, SEM Sample Coaters, Technical ceramics, Thin Film Services, Contact Us, Solar Cell thin film materials, and Li Battery. Further right are icons for search, user profile, shopping cart, and currency (USD). The main content area features the heading 'Materials for Research and Development' followed by a list of product categories: High Purity Evaporation Products, Sputtering and PLD targets, Precision hard Ceramic machining, Single Crystal wafers, and Lowest Cost Carbon evaporators.

himet-materials.com

High Quality, Lowest Cost Sputter & PLD Targets, Evaporation & Single Crystal materials , Ceramic machining, Sputtering Systems & Thermal evaporators for SEM Sample Preparation and thin film research

HIMET
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Search User Cart USD

Materials for Research and Development

- High Purity Evaporation Products
COA provided with every shipment.
- Sputtering and PLD targets , Low gas incorporation. Fine, Uniform grains.
Perovskite based organic and inorganic Solar cell Material.
Unique Customized target compositions and sizes
- Precision hard Ceramic machining- SiN, SiC, ZrO₂, Macor, TiB₂
Single Crystal wafers, rods
- Lowest Cost Carbon evaporators and metal sputter systems for SEM sample preparation and thin film research .
NEW- C coated SiO powder for Li ion battery anode

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PSMA Magnetics Committee –Magnetics Committee Forum on PSMA Website February 28, 2024

- Ongoing discussion to create a Short Videos Tab on Magnetics Forum to address specific topics of general interest
 - This could be the home of a “Magnetics Are Everywhere” introductory video
 - These can be simple redirects to urls already established by PSMA members
 - Helps traffic to magnetics forum
 - Increases audience access for PSMA member companies

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PSMA Magnetics Committee Meeting Agenda – Next Meeting

February 28, 2024

- Next meeting - teleconference
 - Date: Wednesday March 27, 2024
 - Time: 10:00 AM CDT – 11:00 AM CDT



PSMA Magnetics Committee Meeting

February 28, 2024

- Attendance (21)
 - John Horzepa
 - Joe Horzepa
 - Mike Arasim
 - Minjie Chen
 - Thomas Gulloid
 - Ed Herbert
 - Justin Henspeter
 - Bryce Hesterman
 - Marcin Kacki
 - Hoaran Li
 - Lukas Mueller
 - Jonas Muhlethaler
 - Raj Nataraj
 - Ken Pagenkopf
 - PM Raj
 - Mike Ranjam
 - Marek Rylko
 - Uppili Sridhar
 - George Slama
 - JC Sun
 - Matt Wilkowski



Thank You

