2nd IEEE International Challenge in Design Methods for Power Electronics

2025 IEEE Power Electronics Society

MagNet Challenge 2

"From Steady-State to Transient Models!"

Tutorial Session 6, Oct. 30th, 2025

Hyukjae Kwon, Shukai Wang, Haoran Li, Thomas Guillod, Minjie Chen, Charles R. Sullivan

GitHub Repository: https://github.com/minjiechen/magnetchallenge-2
pelsmagnet@gmail.com
MagNet 2025 Organizing Team

IEEE POWER ELECTRONICS SOCIETY
Powering a Sustainable Future

IEEE
Advancing Technology for Humanity

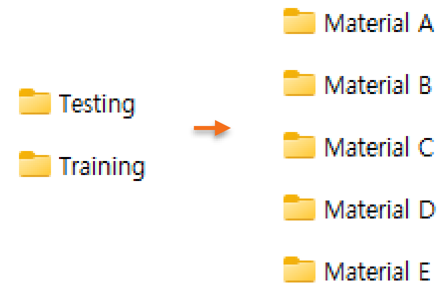
Agenda

IEEE POWER ELECTRONICS SOCIETY

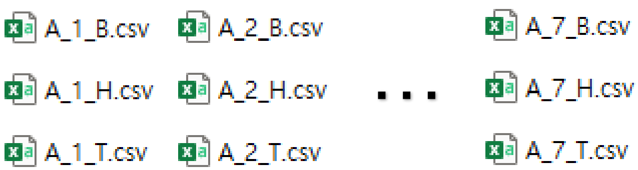
- **Webinar 1 – Data and Neural Network Methods**
  - May 16th Friday, 9 AM EST
- **Webinar 2 – Analytical Methods (by Dr. Thomas Guillid)**
  - May 23rd, Friday, 9 AM EST
- **Webinar 3 – Model Testing and Evaluation Rules**
  - May 30th, Friday, 9 AM EST
- **Webinar 4 – Brainstorm and Q&A**
  - June 6th, Friday, 9 AM EST
- **Webinar 5 – Pre-Evaluation Rules**
  - Sept 12th, 10 AM EST
- **Webinar 6 – Evaluation Datasets**
  - Oct 30th, 10 AM EST

Final Evaluation Dataset

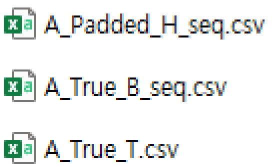
- **5 new materials** will be provided, labeled **A – E** (anonymous for fair evaluation)



- **Training data** includes 3 kinds of CSV files:
  - ✓ **B** (T): Magnetic flux density sequences
  - ✓ **H** (A/m): Magnetic field strength sequences
  - ✓ **T** (℃): Temperature



- **Testing data** includes 3 CSV files:
  - ✓ **B** (T): B input segments for prediction
  - ✓ **H_padded** (A/m): H_{past} input segments for prediction
  - ✓ **T** (℃): Temperature



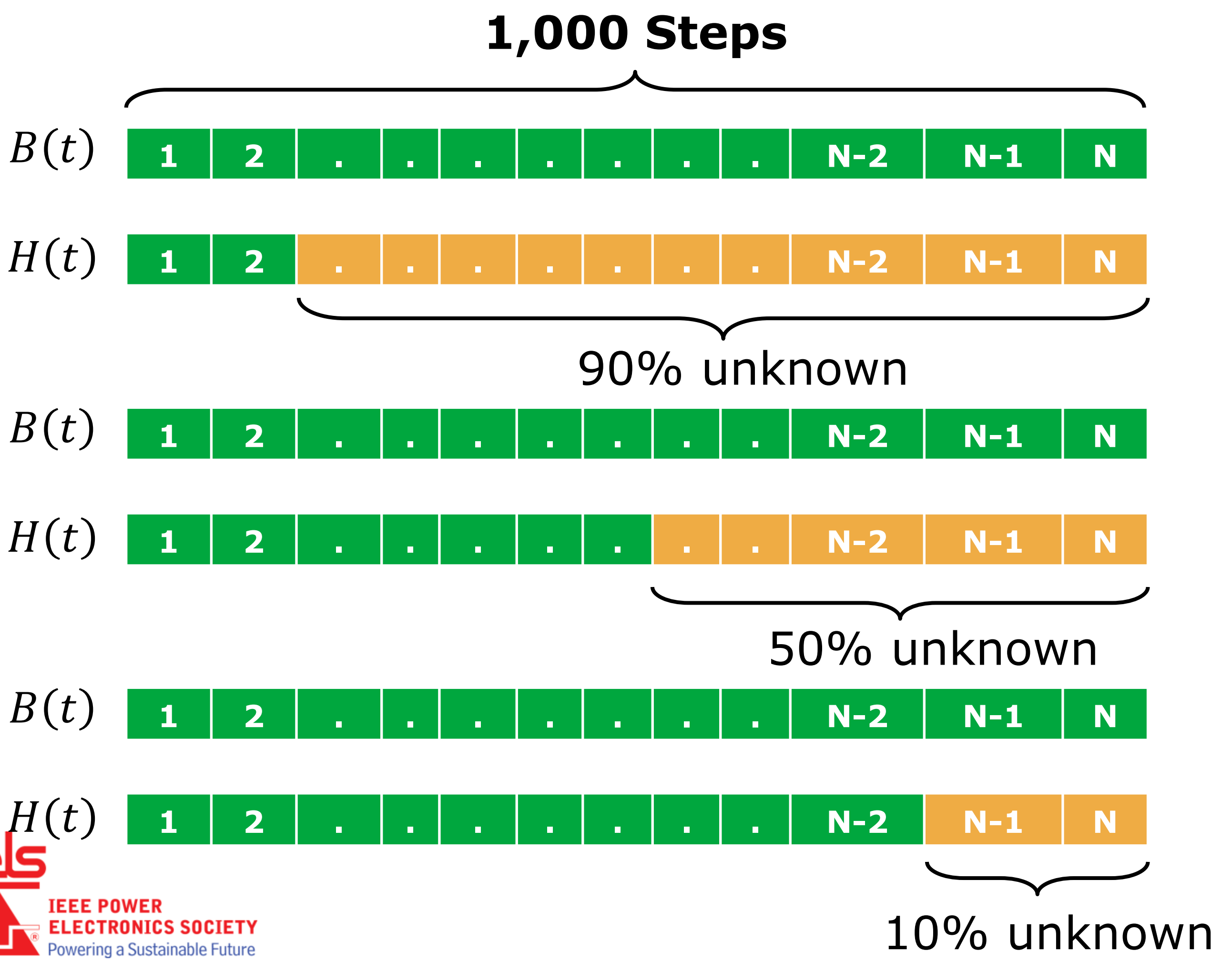
Evaluation Data Format

Sampling frequency!
- 16 MHz
- 62.5 ns

Temp

Input (Known values)

Output (Unknown values)



Frequency
- 50 kHz
- 80 kHz
- 125 kHz
- 200 kHz
- 320 kHz
- 500 kHz
- 800 kHz

~ 1,000 total segments per material

Temperature
- 25 ℃
- 50 ℃
- 70 ℃

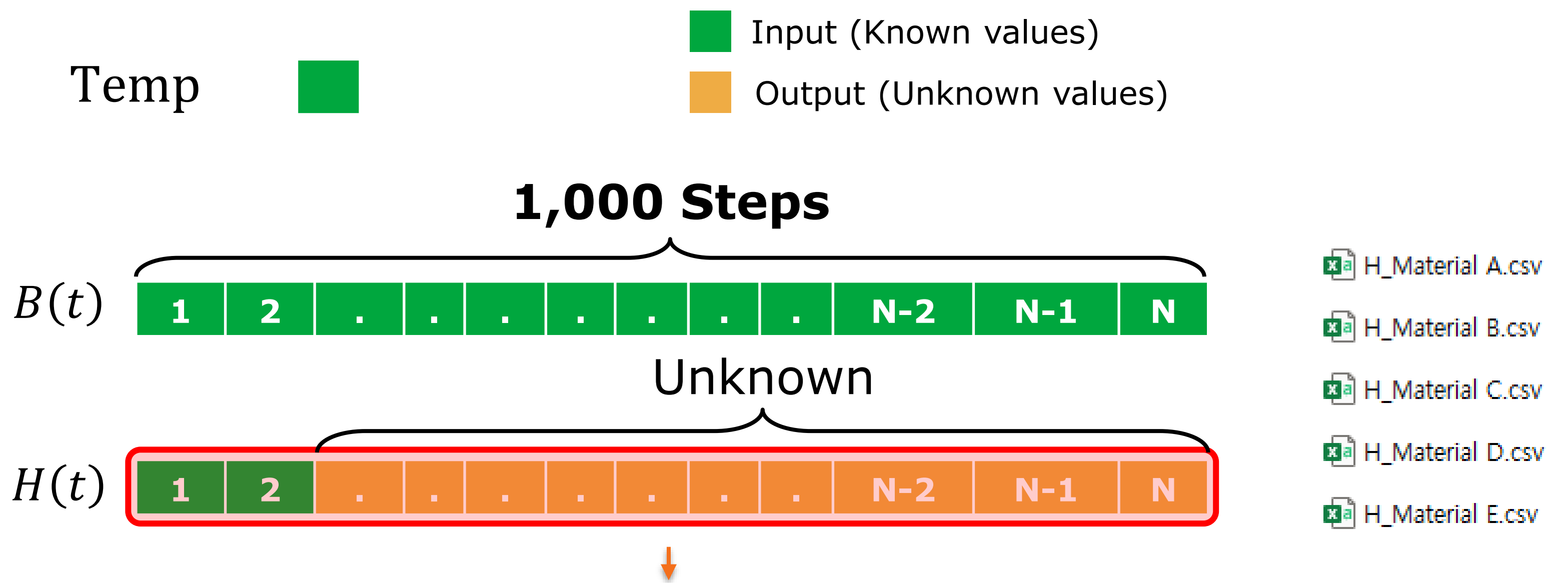
Evaluation Data Submission

❖ Objective

- Fill the unknown part of each H(t) sequence using your model's prediction

❖ Submission Rules

- **Order must match** the provided sequence order exactly
- Submit the **entire H(t) sequence** (both known and unknown part)
- Example:



What you have to submit as CSV files

Evaluation Data Submission

❖ Example

- Fill **all NaN values** in <Material>_Padded_H_seq.csv for all the data points.
- Save and submit the predicted H sequences with the following file name format: H_<Material>.csv.

Padded H(t)

A_Padded_H_seq.csv

-8.49599	-8.36715	-8.23366	-8.09773	-7.96362	NaN	NaN	NaN	NaN	NaN	NaN	NaN
-30.4864	-30.6763	-30.8635	-31.0505	-31.237	NaN	NaN	NaN	NaN	NaN	NaN	NaN
-42.7195	-42.4582	-42.2013	-41.9464	-41.6952	NaN	NaN	NaN	NaN	NaN	NaN	NaN
56.55421	56.56421	56.55612	56.53257	56.49615	NaN	NaN	NaN	NaN	NaN	NaN	NaN

⋮

13.04497	12.92229	12.79854	12.6734	12.54179	12.40666	12.27018	12.13663	NaN	NaN	NaN	NaN
8.874423	8.990281	9.100989	9.20449	9.295536	9.375056	9.449823	9.525291	NaN	NaN	NaN	NaN
4.611583	4.442095	4.2717	4.100907	3.926813	3.751944	3.575455	3.39923	NaN	NaN	NaN	NaN
47.08905	46.74237	46.39632	46.05324	45.70633	45.35984	45.01219	44.66719	NaN	NaN	NaN	NaN

Predicted H(t)

H_Material A.csv

-8.49599	-8.36715	-8.23366	-8.09773	-7.96362	-7.82892	-7.69427	-7.55962	-7.42497	-7.29032	-7.15567	-7.02102
-30.4864	-30.6763	-30.8635	-31.0505	-31.237	-31.424	-31.6109	-31.7978	-31.9847	-32.1716	-32.3585	-32.5454
-42.7195	-42.4582	-42.2013	-41.9464	-41.6952	-41.4393	-41.1849	-40.9305	-40.6761	-40.4217	-40.1674	-39.913
56.55421	56.56421	56.55612	56.53257	56.49615	56.48033	56.45756	56.43479	56.41202	56.38925	56.36648	56.34371

⋮

13.04497	12.92229	12.79854	12.6734	12.54179	12.40666	12.27018	12.13663	12.00082	11.86562	11.73042	11.59522
8.874423	8.990281	9.100989	9.20449	9.295536	9.375056	9.449823	9.525291	9.602435	9.678838	9.755242	9.831645
4.611583	4.442095	4.2717	4.100907	3.926813	3.751944	3.575455	3.39923	3.223551	3.047627	2.871703	2.69578
47.08905	46.74237	46.39632	46.05324	45.70633	45.35984	45.01219	44.66719	44.32012	43.97362	43.62711	43.28061

Submit the entire 1,000 Steps

Evaluation Criteria

- 1. Sequence Relative Error:

$$\mathrm{Err}_{seq} = \frac{RMS(\overbrace{H_{pred}}^{\text{Prediction}} - \overbrace{H_{meas}}^{\text{Provided}})}{RMS(H_{meas})} \times 100\%$$

  - How well the predicted sequence fits the characteristic response of the input data.

- 2. Normalized Energy Relative Error:

Provided or calculate

$$\mathrm{Err}_{ene} = \frac{\int_{t_1}^{t_2} \frac{dB}{dt} \cdot H_{pred}(t)dt - \int_{t_1}^{t_2} \frac{dB}{dt} \cdot H_{meas}(t)dt}{\underbrace{\int_{t_0}^{t_3} \frac{dB}{dt} \cdot H_{meas}(t)dt}_{\text{Provided (core loss)}}} \times 100\%$$

Prediction

  - t_0: start of full sequence, t_3: end of full sequence
  - t_1: start of test segment, t_2: end of test segment
  - How does the **core loss error of predicted segment** compare to the total **core loss** of the entire sequence?

IEEE POWER ELECTRONICS SOCIETY
Powering a Sustainable Future

IEEE Advancing Technology for Humanity

Data Provided

- The **number of sequences** of each materials is provided in the following table:

	Tiny data Challenge	Frequency Challenge	No past H data Challenge	Flux density Challenge	Special material Challenge
Number of Sequences	**Material A**	**Material B**	**Material C**	**Material D**	**Material E**
Training Sequences	105	6,758	8,158	9,536	6,901
Testing Sequences	1,260 out of 12,405	963 out of 2,656	1,119 out of 5,439	1,242 out of 6,357	1,089 out of 4,601

- The **training and testing sequences** are **selected differently** for each materials for the purpose of the Magnet Challenge 2.
- **Training and testing sequences** will be released on **Nov. 15th**.
- The **complete dataset** will be released after the MagNet challenge 2 is completed.

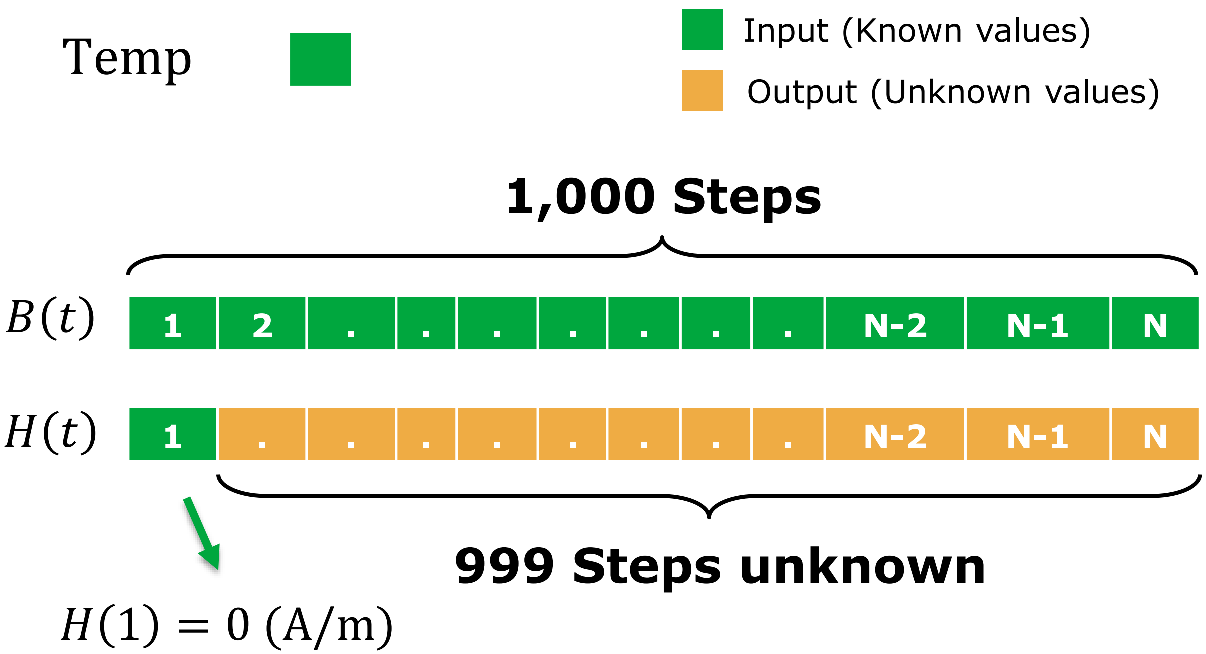
IEEE POWER ELECTRONICS SOCIETY
Powering a Sustainable Future

IEEE
Advancing Technology for Humanity

Evaluation Data Format

❖ **Material C** – No past H data challenge

Sampling frequency!
- 16 MHz
- 62.5 ns



Frequency
- 50 kHz
- 80 kHz
- 125 kHz
- 200 kHz
- 320 kHz
- 500 kHz
- 800 kHz

Temperature
- 25 ℃
- 50 ℃
- 70 ℃

- Only the **initial value** of H is provided (0 A/m).
- No previous H sequence data is given**, unlike the other materials**.

Result Submission

- Please follow the steps below to ensure a smooth and accurate evaluation:
  - ➢ **Rename** the main folder with your **team's name** (e.g., the name of the university)
  - ➢ Put all the **output CSV files** inside the subfolder named “**Result**”.
    - ❖ In a **Parameter_Size.csv** file, clearly indicate **the number of parameters** in your model for **each materials (A – E)**. The table below shows an example:

	Material A	Material B	Material C	Material D	Material E
Number of Parmaters	13,782	19,451	10,237	16,894	10,237

  - ➢ (Jan. 15th) **Compress the entire folder as a ZIP file** for submission.

Submission_TeamName.zip → Result → H_Material A.csv, H_Material B.csv, H_Material C.csv, H_Material D.csv, H_Material E.csv, Parameter_Size.csv

  - ➢ (Jan. 31st) Submit **4-page final report (.pdf)**. TeamName_MagNetX Report.pdf

Conclusion

1. Training Phase

- **November 15th, 2025** – Release of final evaluation data
    1) Download the new **training and testing datasets** from the following link for the **five additional materials (A – E)**
        - MagNet Challenge GitHub: https://github.com/minjiechen/magnetchallenge-2
          Or MagNetX GitHub: https://github.com/PaulShuk/MagNetX
    2) Use the training data **to train, tune, and refine** your model or algorithm.
    3) Predict the **energy loss** for the provided segments and **future H sequences**, filing all **NaN values** in `Material_Padded_H_seq.csv` for all the data points.

2. Final Model

- **January 15th, 2026** – Final model and results submission
    1) Submit **prediction results** as **five separate CSV files** (one for each material) with the number of parameters for each material.
    2) Submit all required files to **pelsmagnet@gmail.com**

3. Final Report

- **January 31st, 2026** – Final report submission
    1) Include a **4-page report (IEEE TPEL format, PDF)** briefly describing your key methods and concepts.
- **February 2026** – Submit trained models for validation and ranking