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 5, Sept. 12th, 2025

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

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Challenge 2

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Agenda

- **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

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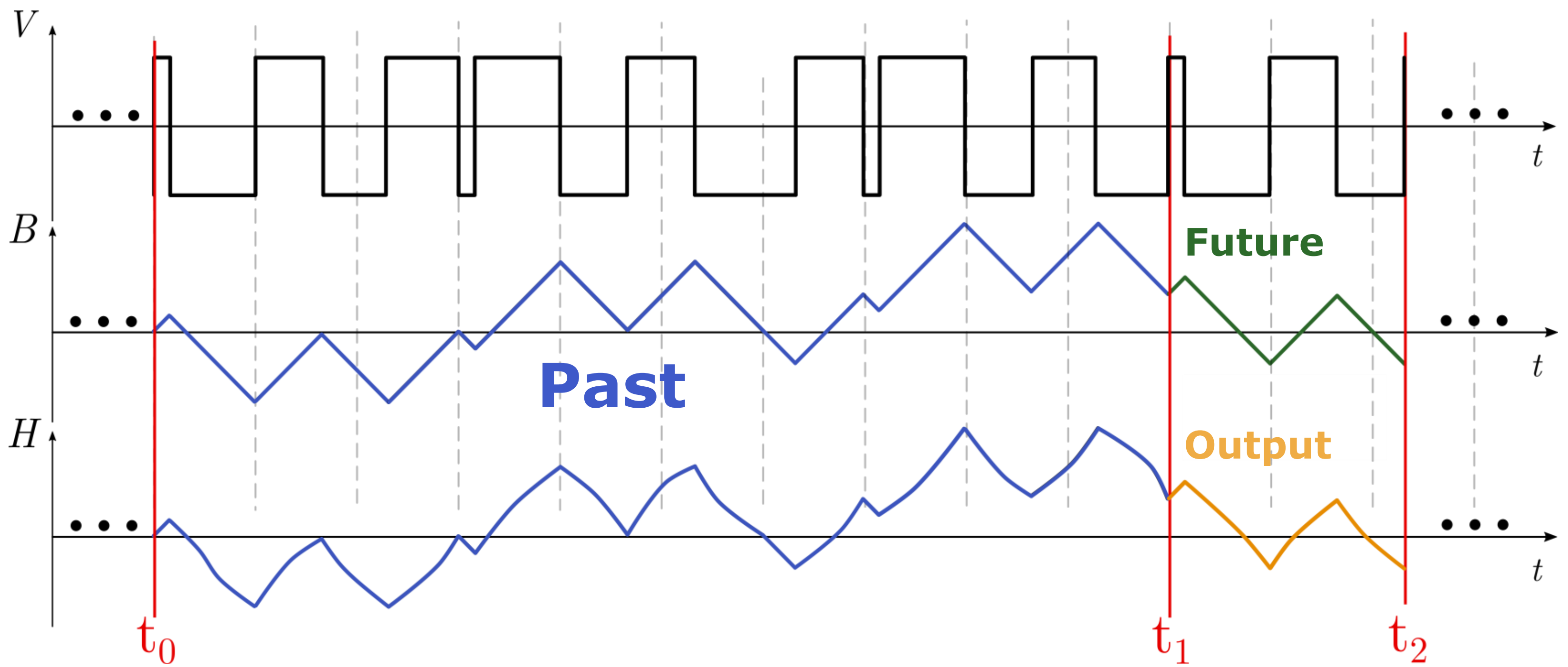
Outcome: A Callable Prediction Function

Output | Your Model | Past | Future

$$H_{t_1 \to t_2} = function\,(B_{t_0 \to t_1}(t), H_{t_0 \to t_1}(t), B_{t_1 \to t_2}, T)$$

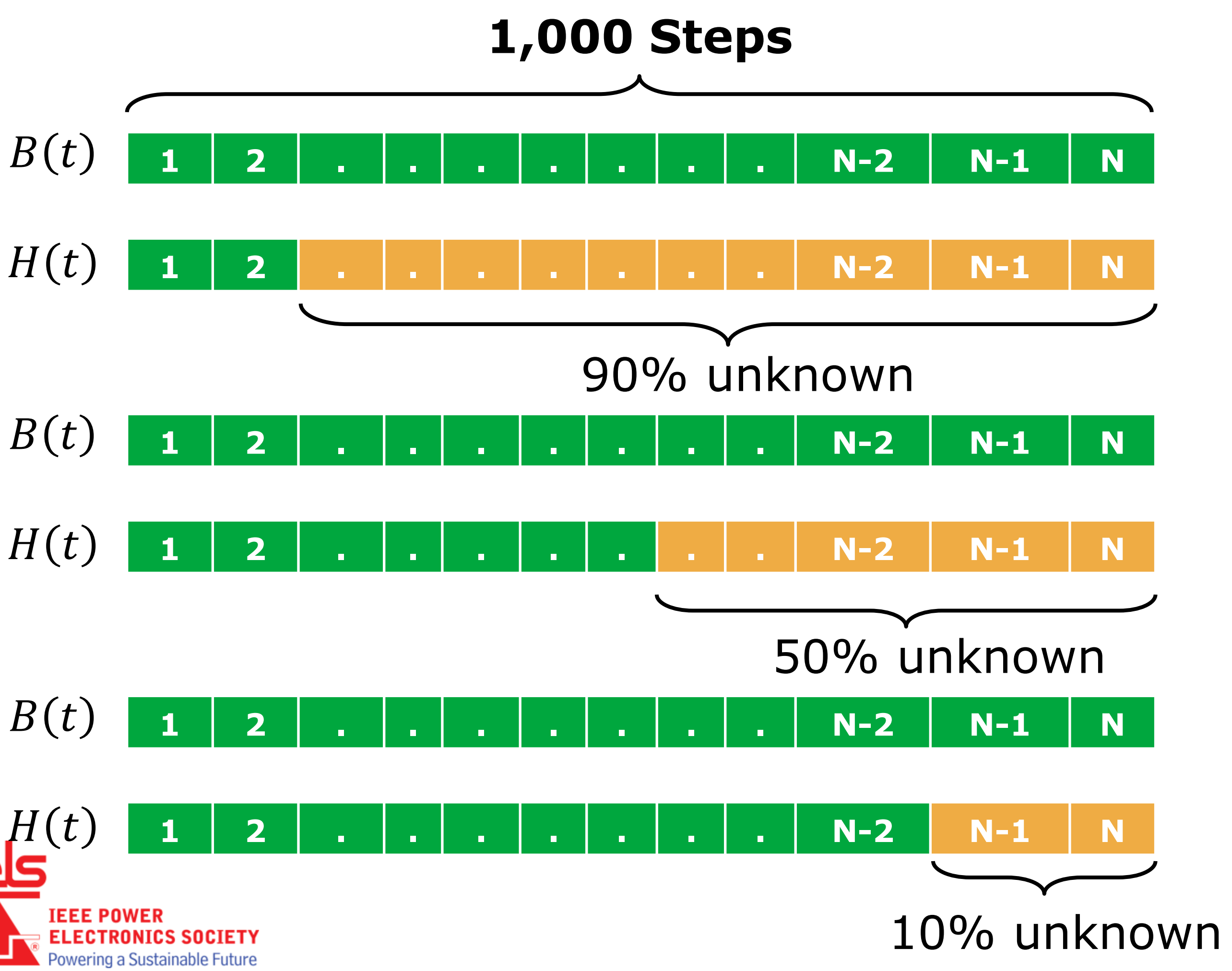


- Hyukjae Kwon, Shukai Wang, Haoran Li, et al. "**MagNetX: Extending the MagNet Database for Modeling Power Magnetics in Transient**," *TechRxiv*. December 11, 2024. Accepted to APEC 2025.

Pre Evaluation Data Format

Sampling frequency!
- 16 MHz
- 62.5 ns

Input (Known values) Output (Unknown values)



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

> 4500 total segments per material

Temperature
- 25 ℃
- 50 ℃
- 70 ℃

Evaluation Criteria

- 1. Sequence Relative Error:

Prediction Provided

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

  - 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

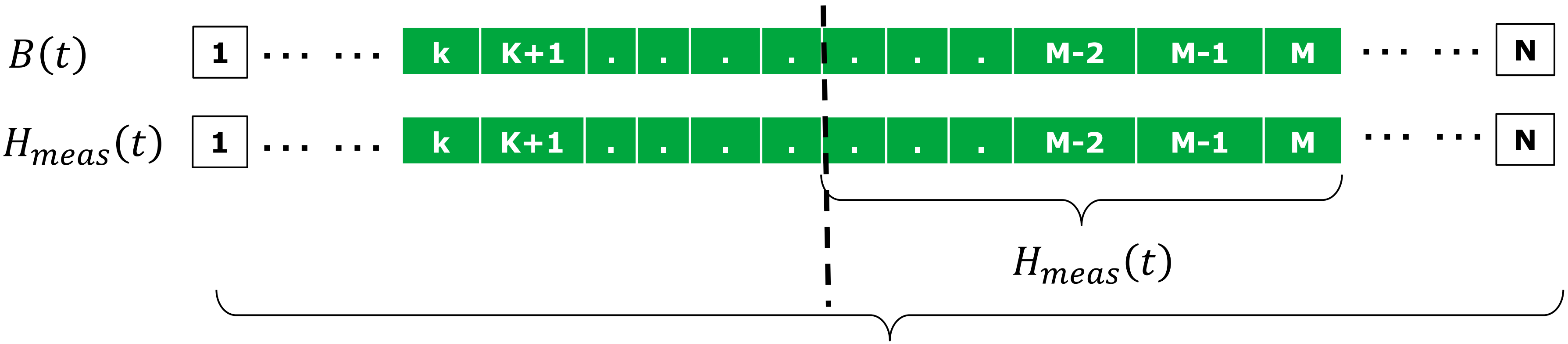
  - t_0: start of full sequence, t_3: end of full sequence
  - t_1: start of test segment, t_2: end of test segment
  - How the segment total energy error compares normalized against the total core loss of the steady state sequence?

Data Provided

Temp

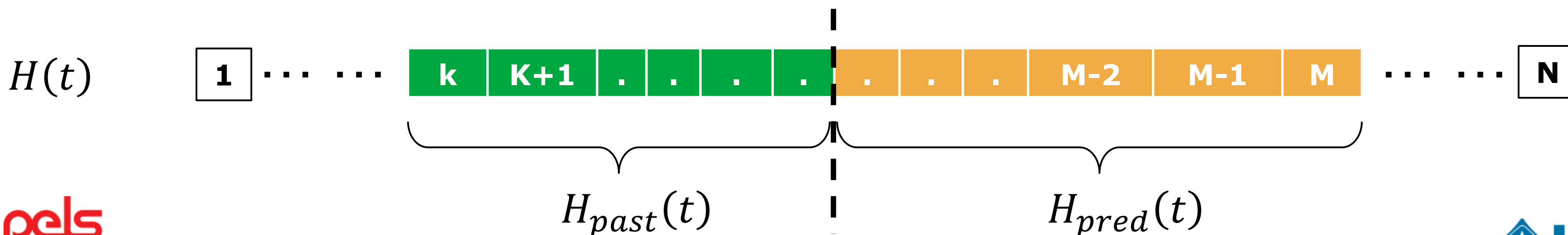
Core Loss

- 1. "Material"_Testing_True



$$\text{Core Loss} = \int_1^N \frac{dB}{dt} \cdot H_{meas}(t)dt$$

- 2. "Material"_Testing_Padded



Model Inference

- Please visit MagNet Challenge GitHub: https://github.com/minjiechen/magnetchallenge-2
- Or MagNetX GitHub: https://github.com/PaulShuk/MagNetX

1. Data Saving: PreTest_Save.mat

- 1. "Material"_Testing_True
  - Original B excitation segment
  - Original H excitation segment
  - Temperature for each segment
  - Full sequence core loss value for each segment
- 2. "Material"_Testing_Padded
  - Partially provided H segment

```
% Saving B, H, Temp and core loss in full measurement data.
file_save_name = fullfile(path_root_save, [Material,save_name,'.h5']);
h5create(file_save_name, '/B_seq', size(B_test_all'));
h5create(file_save_name, '/H_seq', size(H_test_all'));
h5create(file_save_name, '/T', size(T_test_all'));
h5create(file_save_name, '/Loss', size(Loss_test_all'));

h5write(file_save_name, '/B_seq', B_test_all');
h5write(file_save_name, '/H_seq', H_test_all');
h5write(file_save_name, '/T', T_test_all');
h5write(file_save_name, '/Loss', Loss_test_all');
```

```
% Saving H with partial infomration.
file_test_name = fullfile(path_root_save, [Material,test_name,'.h5']);
h5create(file_test_name, '/H_seq', size(H_test_all_past'));

h5write(file_test_name, '/H_seq', H_test_all_past');
```

2. Model Evaluation: Inference.py
3. Result Generation: Error_Distribution_Plot_Template.mat

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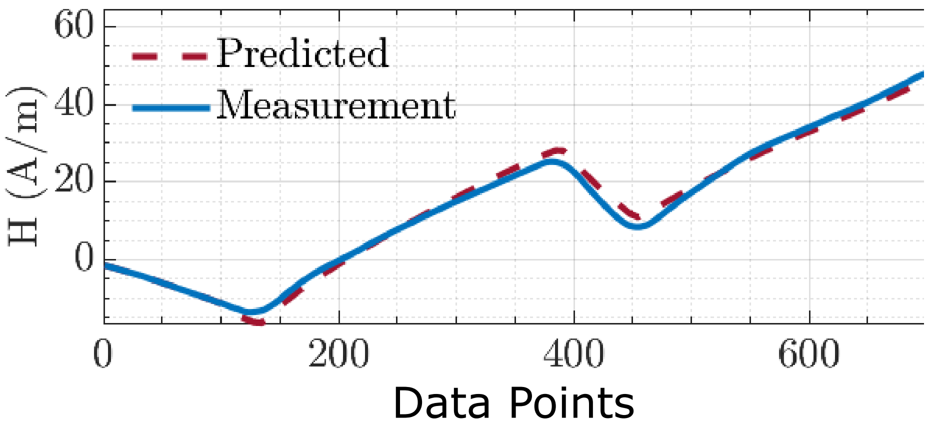
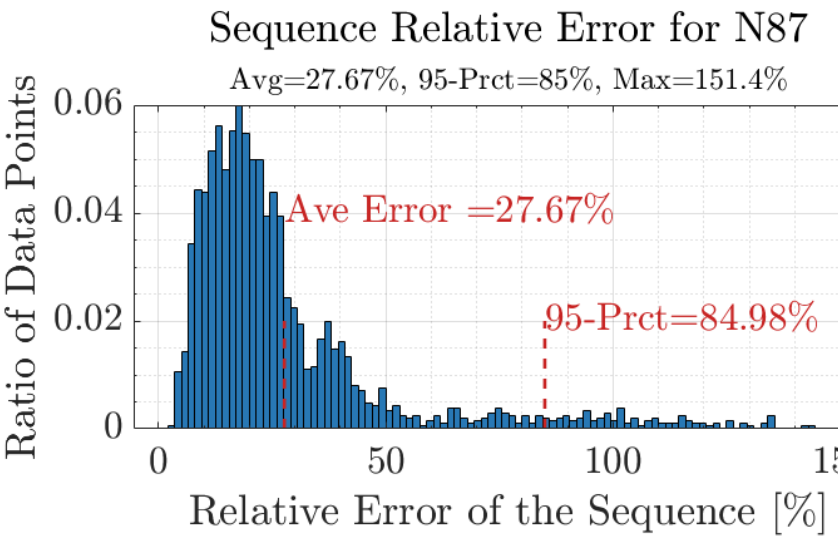
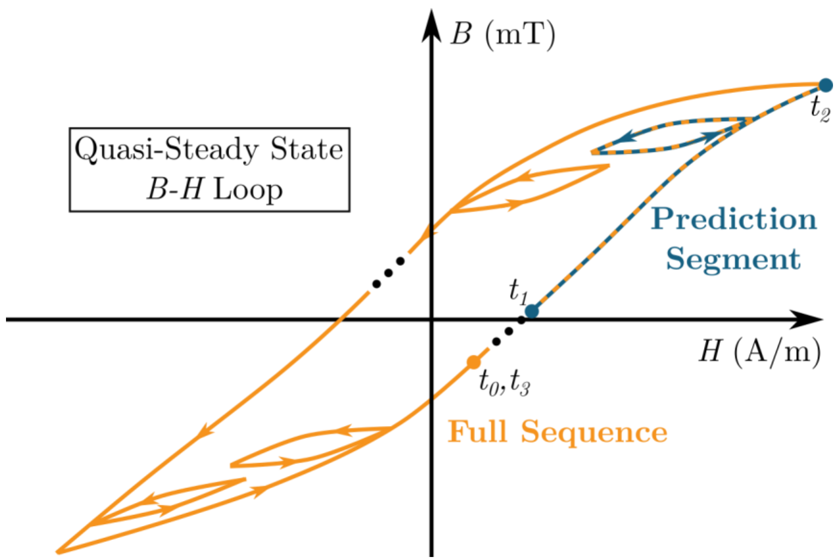
Histogram



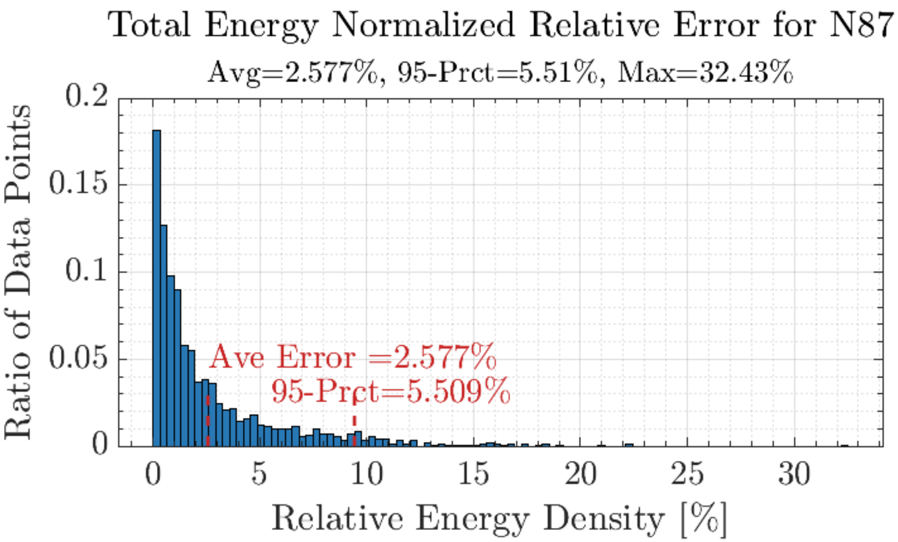
Predicted
Measurement
H (A/m)
Data Points



Sequence Relative Error for N87
Avg=27.67%, 95-Prct=85%, Max=151.4%
Ave Error =27.67%
95-Prct=84.98%
Ratio of Data Points
Relative Error of the Sequence [%]



B (mT)
H (A/m)
Quasi-Steady State
B-H Loop
Prediction
Segment
Full Sequence
t_1
t_2
t_0, t_3



Total Energy Normalized Relative Error for N87
Avg=2.577%, 95-Prct=5.51%, Max=32.43%
Ave Error =2.577%
95-Prct=5.509%
Ratio of Data Points
Relative Energy Density [%]

Conclusion

1. Training data

- 10 training materials
- Lots of long B(t)-H(t) pairs in full sequence length
- Temperature

2. Pre-Evaluation

- Random segments provided within the 10 materials
- Team self Report results given the evaluation rules for N87 and 3C90 materials for all 3 data splitting scenarios
- Result template posted online (Pre_Evaluation_Results)

3. New Materials

- November 15th : Pre-Evaluation submission
- 5 unknown materials partial training data provided

4. Submission

- January 15th : Final model submission
- Final test segments provided to perform final evaluation

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