Literature Search Log

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Project: ML-Based Surrogate Model For Signal Integrity

Date	Database	Search Terms	Results	Useful Hits
30-11-2025	IEEE Xplore	"integrated circuit modelling" AND "signal Integrity applications" AND "Neural Networks"	27	1 (Akinwande et al.)
03-12-2025	IEEE Xplore	"high-density interconnects" AND "machine learning"	43	1 (Sreekumar & Gupta)
07-01-2026	Google Scholar	"physics-informed" AND "interconnects"	1600	3 (Garbuglia et al.) (J. Fan et al) (T. -L. Wu et al.)
12-01-2026	Research Gate	"PCB manufacturing" AND "Impedance" AND "Variation"	540	1 (Abdelghani Renbi et al.)
14-01-2026	IEEE Xplore	"signal and power integrity" AND "channel modeling"	2	1 (Juhitha Konduru et al.)
21-01-2026	IEEE Xplore	"SI/PI Database" AND "Machine Learning"	7	1 (Morten Schierholz et al.)
05-02-2026	IEEE Xplore	"inverse design" AND "Neural Network" AND "channel"	24	1 (Hanzhi Ma et al.)
07-02-2026	arxiv	"inverse problems" AND "Deep Learning"	8	1 (Jaweria Amjad et al.)

2. Log of Articles Reviewed

1. Core reference paper

Citation: O. Akinwande, S. Erdogan, R. Kumar and M. Swaminathan, "Surrogate Modeling With Complex-Valued Neural Nets for Signal Integrity Applications," in IEEE Transactions on Microwave Theory and Techniques, vol. 72, no. 1, pp. 478-489, Jan. 2024, doi: 10.1109/TMTT.2023.3319835. **Key Findings:**

- Proposes the complex-valued Neural Networks method to handle the phase information in machine learning which is the core idea to develop our forward and inverse model. **Relevance**

- This is the primary reference for our forward model.

2. High-Density Interconnects

Citation: D. Sreekumar and S. Gupta, "Efficient Synthesis and Simulation of High-Density Interconnects Using Machine Learning," 2025 IEEE 29th Workshop on Signal and Power Integrity (SPI),Gaeta, Italy, 2025, pp. 1-4, doi: 10.1109/SPI64682.2025.11014451.

Key Findings: *Discussed the sysnthesis of interconnects using machine learning which can be very usefull for data generation. **Relevance** it offers insights on simulation strategy for data generation of high-density designs.

Key Findings:

3. Physics-Informed Modeling

Citation: F. Garbuglia, T. Reuschel, C. Schuster, D. Deschrijver, T. Dhaene and D. Spina, "Modeling Electrically Long Interconnects Using Physics-Informed Delayed Gaussian Processes," in IEEE Transactions on Electromagnetic Compatibility, vol. 65, no. 6, pp. 1715-1723, Dec. 2023, doi: 10.1109/TEMC.2023.3317917.

Key Findings: This paper used Guassian process which gives insights on physivs informed loss-functions that we refer for model design to make it accurate not just for the exact values but also for the range of values while predicting the output params.

Relevance:

- It is useful for considering how the moedel need to be modified and designed on combining physics informed loss and complex valued neural network.

4. SI Fundamentals

Citation: J. Fan, X. Ye, J. Kim, B. Archambeault and A. Orlandi, "Signal Integrity Design for HighSpeed Digital Circuits: Progress and Directions," in IEEE Transactions on Electromagnetic Compatibility, vol. 52, no. 2, pp. 392-400, May 2010, doi: 10.1109/TEMC.2010.2045381.

Relevance

- This paper is used to find the problem statement that we are solving which gives foundational knoledge on the non-ideal effects (skin-effects and surface roughness)

5. PCB Technology Overview

Citation: T. -L. Wu, F. Buesink and F. Canavero, "Overview of Signal Integrity and EMC Design Technologies on PCB: Fundamentals and Latest Progress," in IEEE Transactions on Electromagnetic Compatibility, vol. 55, no. 4, pp. 624-638, Aug. 2013, doi: 10.1109/TEMC.2013.2257796.

Relevance

- This paper gives the context for stochastic manufacturing variations during the manufacture of PCB. This will help us with the project to consider the schotastic variation while predicting the s-params and during the output.

6. Manufacturing variations

Citation Renbi, A.; Carlson, J.; Delsing, J. Impact of pcb manufacturing process variations on trace impedance. In Proceedings of theInternational Symposium on Microelectronics, Long Beach, CA, USA, 9–13 October 2011; International Microelectronics As-sembly and Packaging Society: Pittsburgh, PA, USA, 2008; pp. 000891–000895.

Key Findings The author demonstrates that the use of 1-D convolution neural networks are more efficient and effective than the standard dense layers to capture the high-frequncy ripples in the S-Parameters.

Strength 1_D CNN architecture captures the harmonics in the freqency data i.e. long range dependencies

Weakness In this paper the model addresses only the forward path and no Inverse model is implemented

Relevance This paper provide a reference for improving the architecture for the forward model where the 1-D CNN can be adapted to build the tandem loop to detect the small signal deviations caused by manufaturing defects.

7. Convolution Nets for Forward Modeling

Citation J. Konduru, O. Mikulchenko, L. Y. Foo and J. E. Schutt-Ainé, "Signal Integrity Analysis and Design Optimization using Neural Networks," *2024 IEEE 74th Electronic Components and Technology Conference (ECTC)*, Denver, CO, USA, 2024, pp. 924-928, doi: 10.1109/ECTC51529.2024.00150.

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8. Database for the model

Citation M. Schierholz *et al.*, "SI/PI-Database of PCB-Based Interconnects for Machine Learning Applications," in *IEEE Access*, vol. 9, pp. 34423-34432, 2021, doi: 10.1109/ACCESS.2021.3061788.

Key Findings This paper provides the biggest dataset for SI/PI data of PCB-Based Interconnects for Machine Learning Applications

Relevance We use this data to train the model for our machine learning architecture.

9. Inverse model Tandem Network

Citation H. Ma et al., "Channel Inverse Design Using Tandem Neural Network," 2022 IEEE 26th Workshop on Signal and Power Integrity (SPI), Siegen, Germany, 2022, pp. 1-3, doi: 10.1109/SPI54345.2022.9874935.

Key Findings The paper explores channel inverse design using Tandem neural network to solve non-uniqueness problem in invese design. They connect the inverse network to the pre-trained forward model to converge the geometrics from the s-parameters

Strength Tandem neural net solves the one-to-many mapping problem as there can be multiple geometries that can yield the same s-parameters

Weakness The model just assume the forward model without any optimization wihtout any circuit constraints
Relevance This Tandem Neural Net model cn be adapted as baseline where we can inprovise the architecture further for our model.

10. Algorrithm exploration

Citation J. Amjad, Z. Lyu, and M. R. D. Rodrigues, "Deep Learning for Inverse Problems: Bounds and Regularizers," in arXiv preprint arXiv:1901.11352, 2019.

Key Findings This paper proves that the stability of the solution is directly linked to the spectral norm of the Jacobian matrix for the inverse problems. The neural network can be precvented from being tricked by regularizing the Jacobian.

Strength This provides the theorem connecting Jacobian size to the generelazation errors

Relevance Even though the core concept is focused on image reconstruction, the Jacobian regularization conceept can be adapted to apply in PCB manufacturing yield.