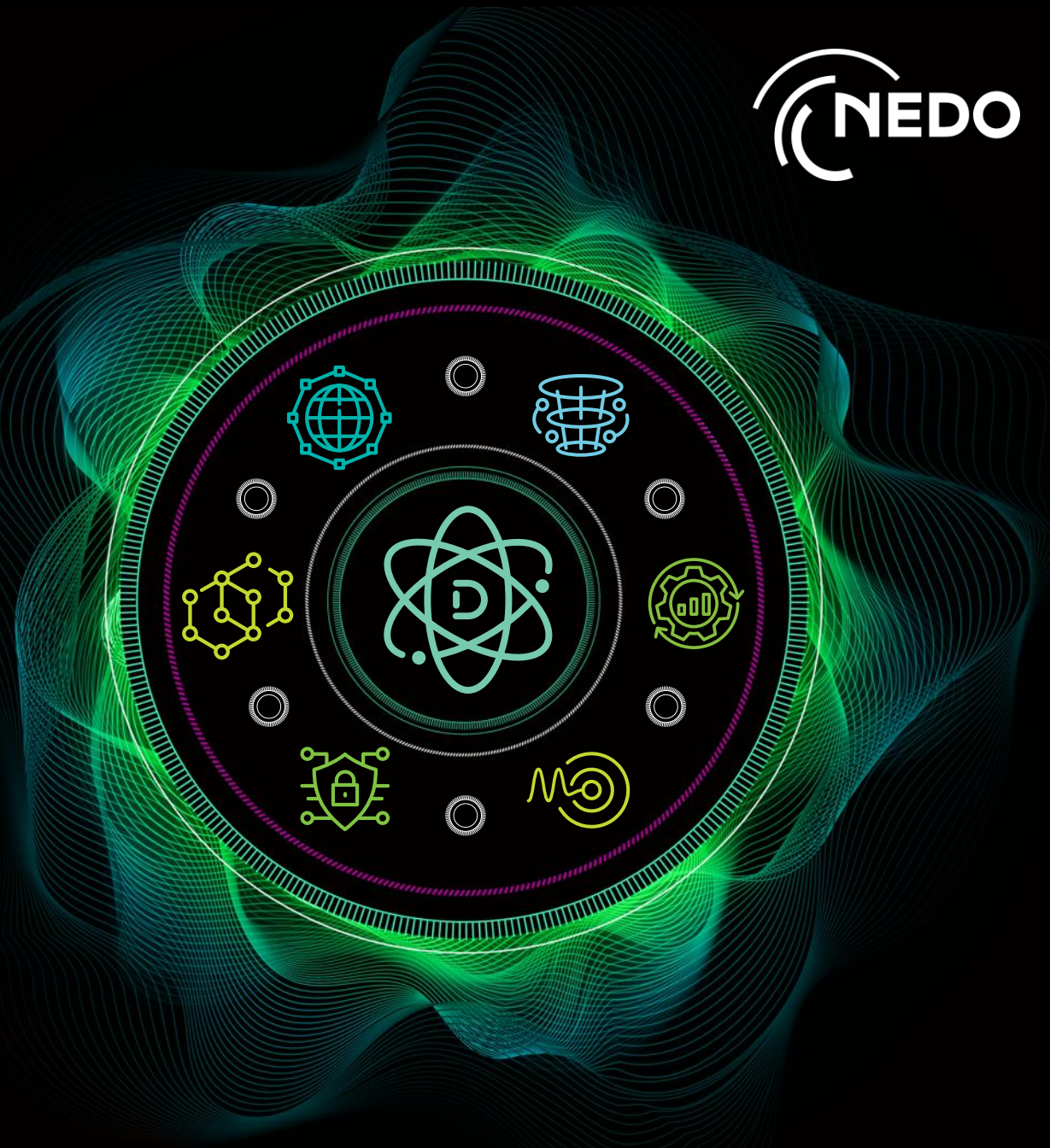
Quantum Computing Use Cases

Optimization of Decoupling Capacitors in Four-Layer Printed Circuit Boards

Fujitsu



New Energy and Industrial Technology Development Organization (NEDO)

Fujitsu: Optimization of Decoupling Capacitors in Four-Layer Printed Circuit Boards [2024/3] 1/2

Validation

Industry	Discrete Manufacturing
Process	R & D and product design
Method	combinatorial optimization
Category	Ising*

Background

- Fujitsu has released a fourth-generation digital annealer using its own technology. **Digital annealer is a computing technology inspired by quantum phenomena that can quickly solve combinatorial optimization problems that are difficult to solve with ordinary computers.**
  - ✓ Large annealing cores implemented on multiple GPUs
- Electromagnetic interference (EMI) is defined as **electromagnetic interference** or "radio wave interference, in which electromagnetic waves emitted by electronic or communication devices have an impact on other devices or systems.
- **In this project, EMI is evaluated to identify the capacitor combination that produces the smallest radiated electric field.**

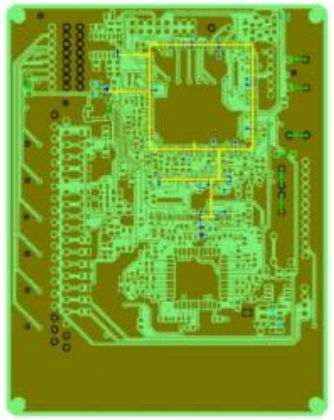
Problem setting as a quantum computer

- Electromagnetic field analysis was performed and the design was optimized by **high-speed search on approximate model by FM-DA and global search by GA (genetic algorithm),** *1 and**),** which combined digital annealer and machine learning. On a 121 × 94 × 1 [mm] substrate, 650,000 steps were performed with 50.4 million gratings, and as a result of analysis, an output of the 10 m method radiation electric field (30 MHz to 1 GHz) was obtained.
- **QUBO Formulation**, *2 and **Automatic Generation by Machine Learning** Required for Digital Annealer
- HW utilizes Fugaku and Fujitsu's proprietary large-scale annealing core technology

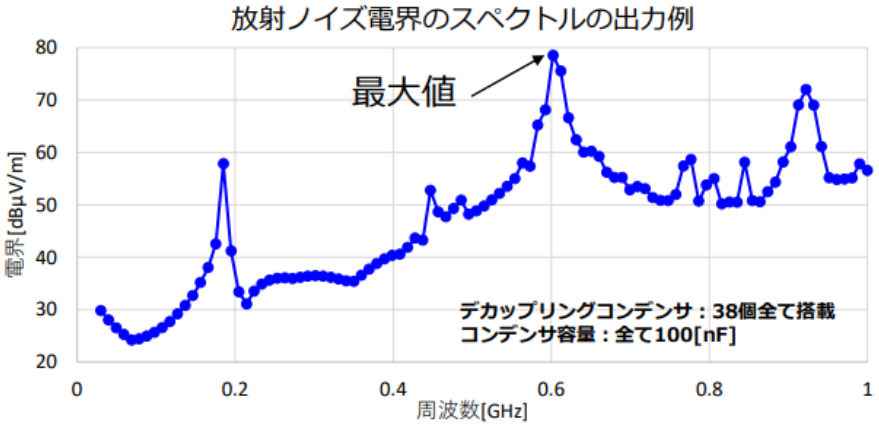
*1: Genetic algorithm is an algorithm that searches for an approximate solution based on the concept of evolutionary theory.
*2: QUBO formulation refers to the formulation as a quadratic polynomial of binary variables feasible for quantum annealing

Issues and motivation to be solved

- **Large-scale calculations are required to optimize the number and capacitance of decoupling capacitors for noise reduction. For example, if there are 38 capacitors and no capacitance or 7 levels of capacitance, a total of 2.07×1034 combinations are generated.**
- **Design optimization achieved by reducing the number of capacitors while reducing noise electrolysis**



analytical model



analysis result
(10 m method: Emission electric field (30 MHz to 1 GHz))

Reference: Fujitsu Limited, "Up to this point, HPC✕ Electromagnetic Field Analysis" (https://www.hpci-office.jp/documents/workshop/cae-ws.240308_Kochibe.pdf)
*Ising: A computing approach, mainly associated with quantum annealers and simulators specialized for the Ising model, in which a problem is first formulated as an Ising model and then solved computationally. It is particularly well suited to problems that involve finding the optimal combination from a vast number of possibilities.

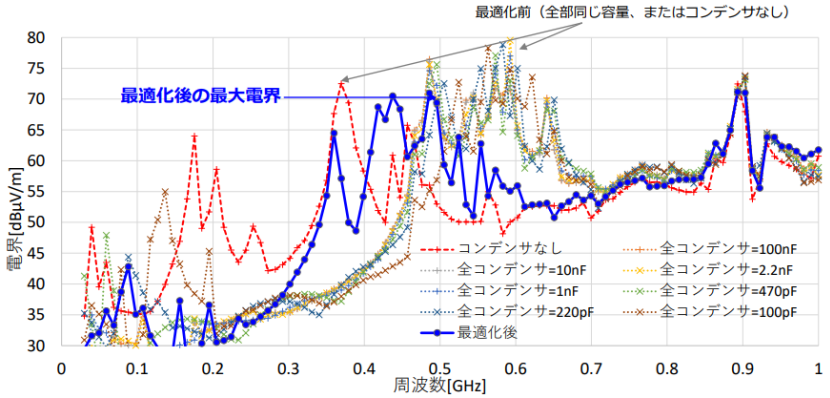
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Expected business benefits

- For a 4-layer printed circuit board, the maximum electric field value of 72.52~79.55 [dBμV/m] was reduced from 38 capacitors before optimization to **20 capacitors 71.18 [dBμV/m]**, reducing the number of capacitors by approximately half while suppressing the noise electric field.



Optimization Results by FMDA+GA

C9000	C9001	C9002	C9004	C9005	C9006	C9009	C9011	C9014	C9016	C9017	C9019	C9021	C9022	C9023	C9024	C9027	C9028	C9029
なし	10nF	1nF	100nF	なし	1nF	なし	1nF	100pF	なし	1nF	100pF	1nF	なし	なし	なし	470pF	なし	なし
C9030	C9035	C9036	C9043	C9044	C9047	C9048	C9057	C9058	C9069	C9070	C9071	C9072	C9073	C9074	C9075	C9076	C9077	C9078
なし	なし	100pF	10nF	100pF	1nF	なし	なし	なし	2.2nF	なし	2.2nF	なし	2.2nF	なし	なし	220pF	220pF	470pF

Optimization result of capacitor presence and capacitance value

Reference: Fujitsu Limited, "Up to this point, HPC✕ Electromagnetic Field Analysis" (https://www.hpci-office.jp/documents/workshop/cae-ws.240308_Kochibe.pdf)
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More use cases are available on our website. We invite you to explore them.
https://www.quantum-computing-use-cases.nedo.go.jp/english/

More Use Cases

New Energy and Industrial Technology Development Organization (NEDO)
AI and Robotics Department (e-mail: quantum_ai@ml.nedo.go.jp)

This collection of use cases was obtained as a result of the work commissioned by the New Energy and Industrial Technology Development Organization (NEDO) "Cyber-Physical Development Business of Quantum/Classical Hybrid Technology/Study of Use Case of Quantum Technology" and the “Post-5G Information and Communications System Infrastructure Reinforcement R & D Project (Quantum Industrialization)/Comprehensive Study for Promoting the Industrialization of Quantum Computers”.