A Study on Circular-coil Characteristics for Displaying Non-contact Tactile Sensation based on Magnetic Field.

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More than 20 years in human brain function study using fMRI.
Now He is doing research using fNIRS and EEG.

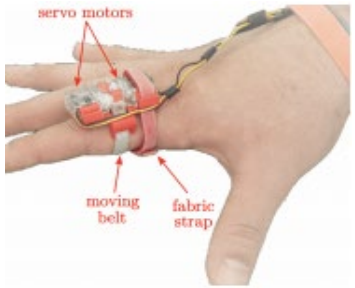
Research interests in
Analysis of tactile perception and cognition.
Development of non-contact tactile display system.

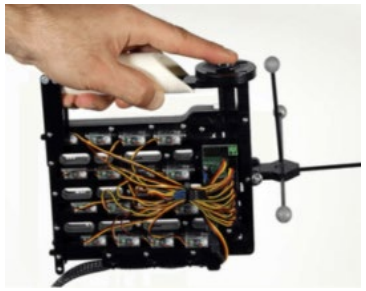
Contents

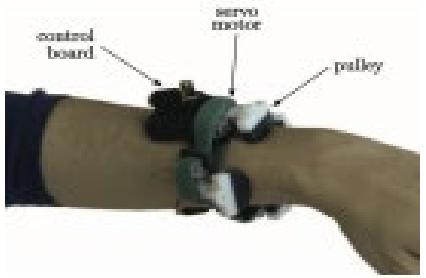
Introduction - Mid-Air Haptics

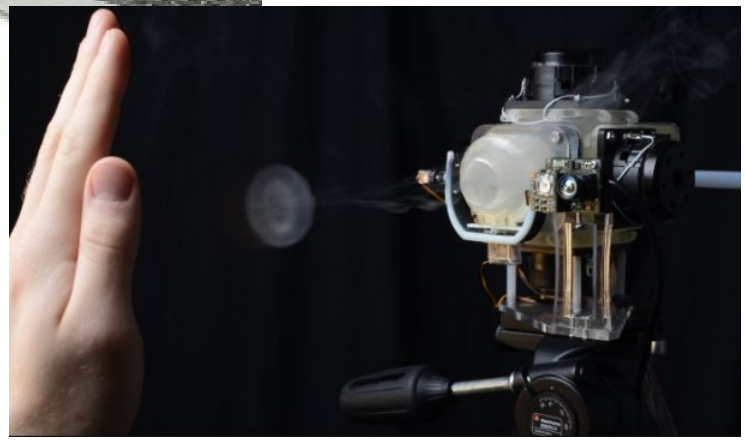
- Two strategies to produce haptic feedback

Contact → Have to hold and/or wear the device equipped an actuator
Non-Contact → Do not need to hold and/or wear the device equipped an actuator



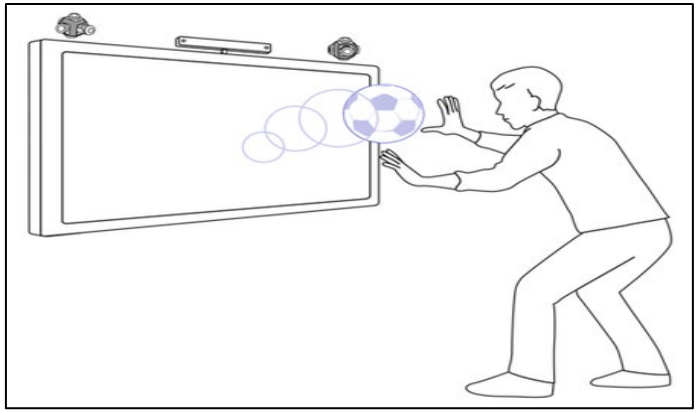






Motivation - Comparison of actuation sources

Ultrasound (BOSCH Corps.,)

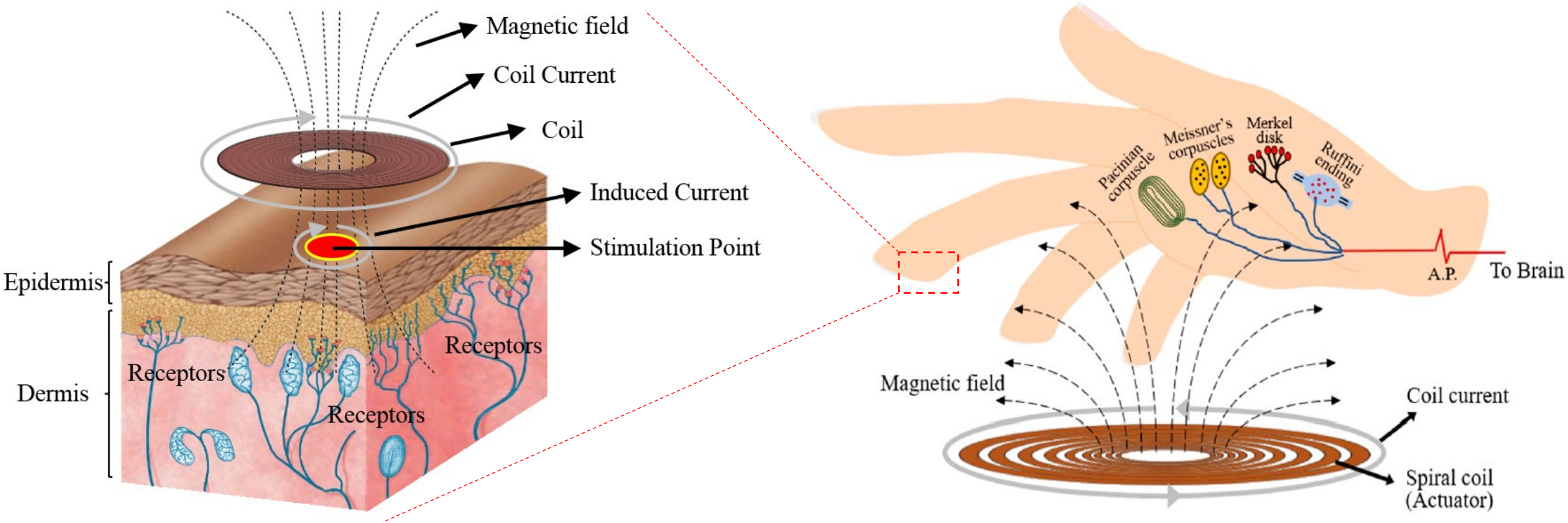


Compressed Air (Disney Lab.)

	Ultrasound	Compressed Air
Intensity	Controllable	Not controllable
Spatial resolution	Low	Low
System dimension	Small	Small
Working Distance	About 30 cm	About 1 m
Working Noise	Yes	Yes
System complexity	Medium	Complex
Cost	Low	Low

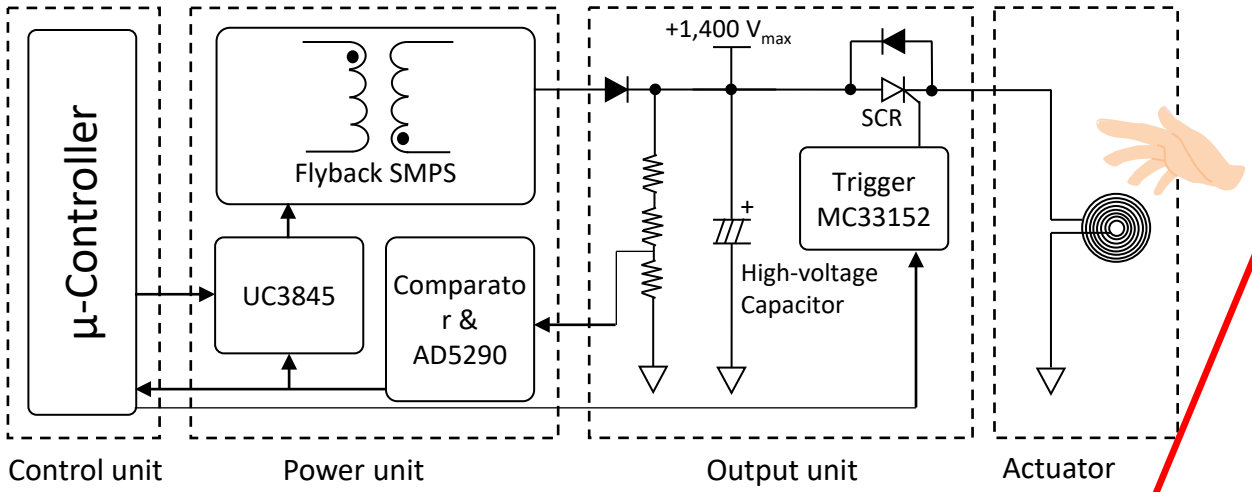
★Motivation → ①Enhance spatial and time resolution
②Prolong working distance
③Elicit a high-functional tactile sensation

Mechanism - Magnetic field and tactile stimulation

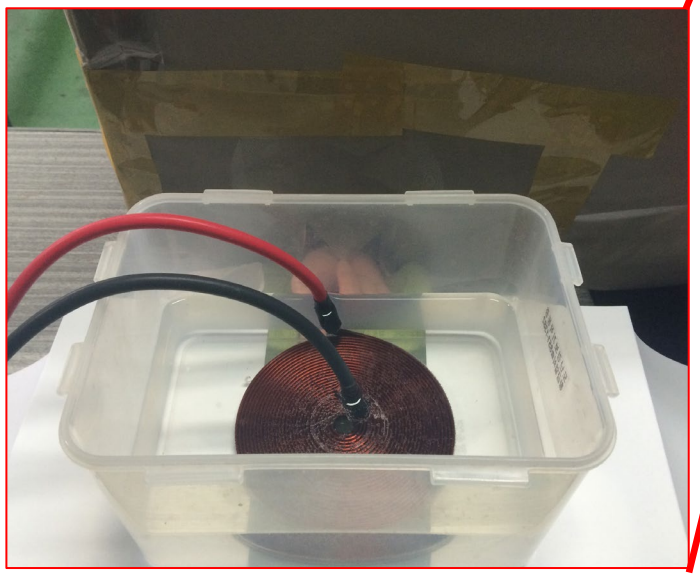


Schematic of the diagram for tactile sensation induced by TSTM
(A.P. refers to Action Potential)

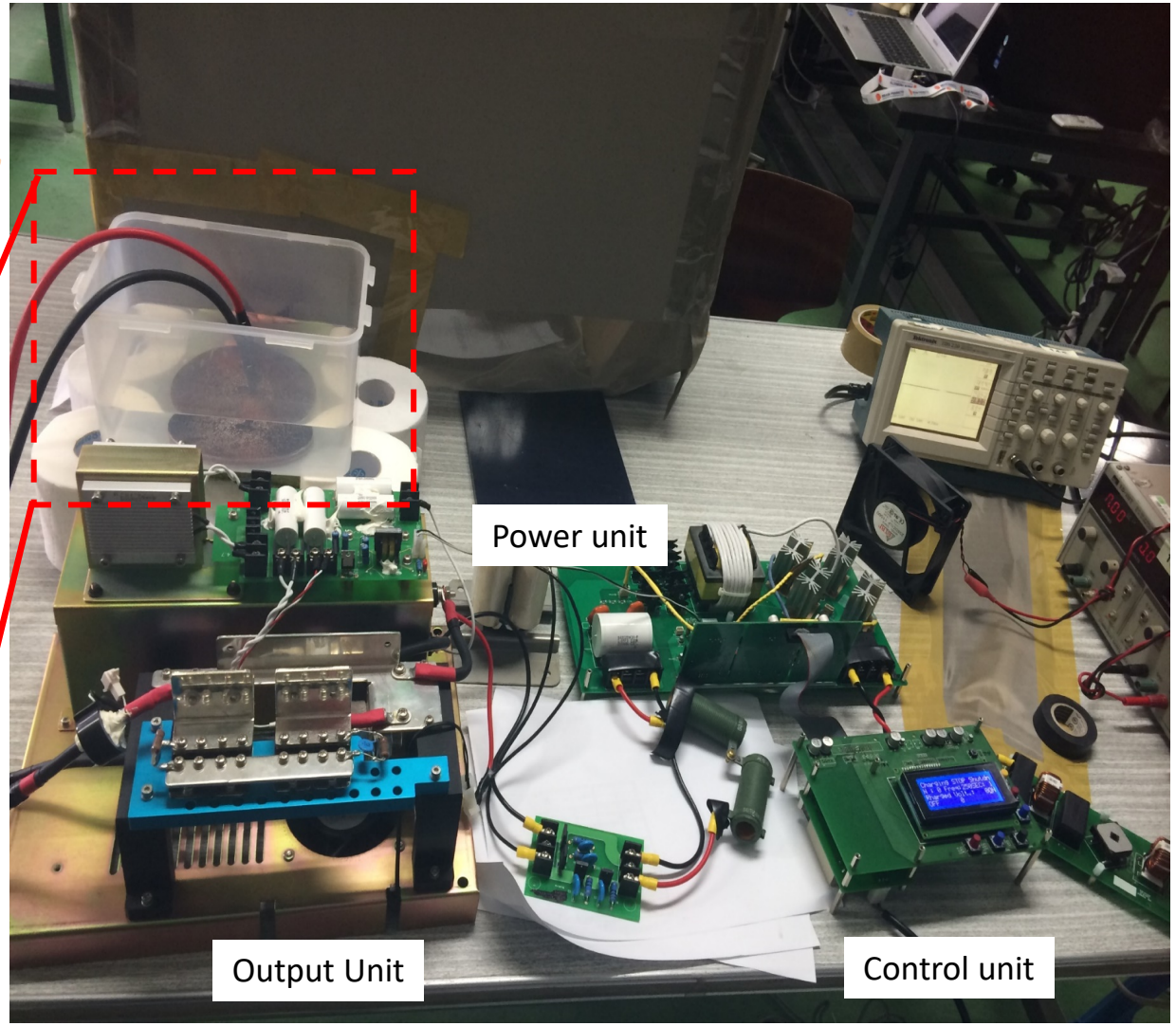
Introduction - Configuration of magnetic field based tactile stimulator and Drawback



Heat dissipation
&
Heatsink required.

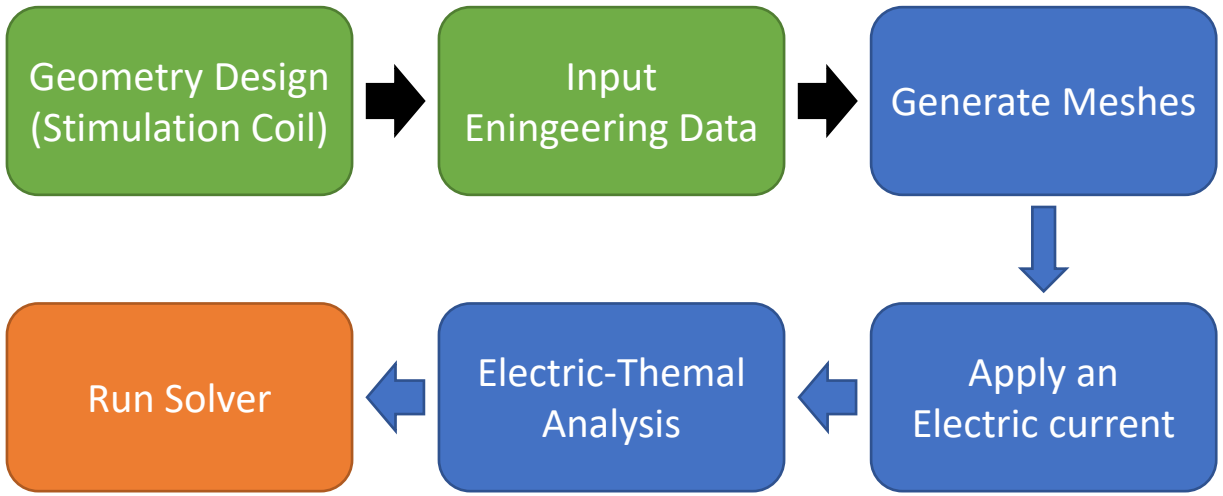


Stimulation coil (Actuator)

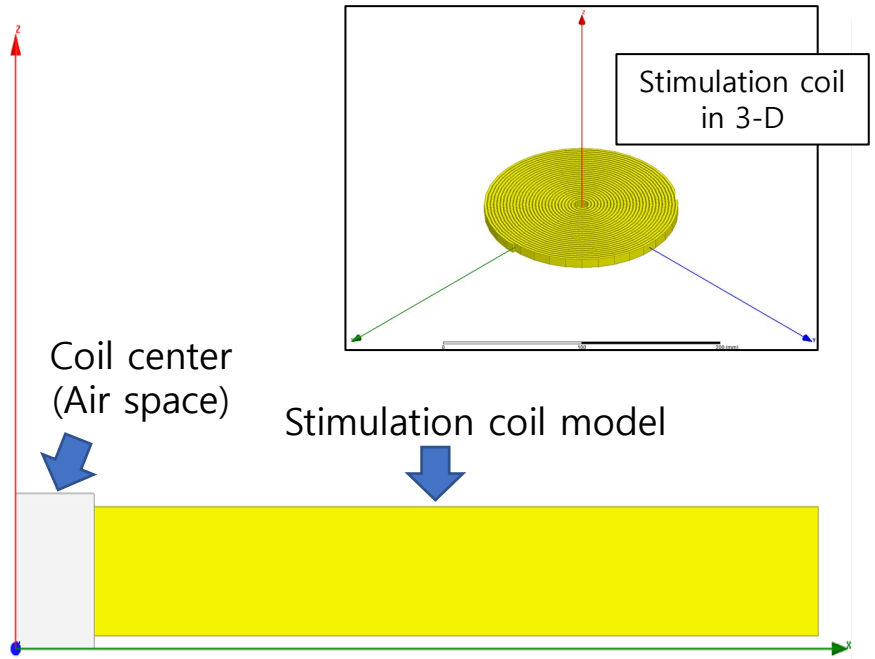


View of Overall system

Method – Simulation environment and Coil geometry design Related eqatuion



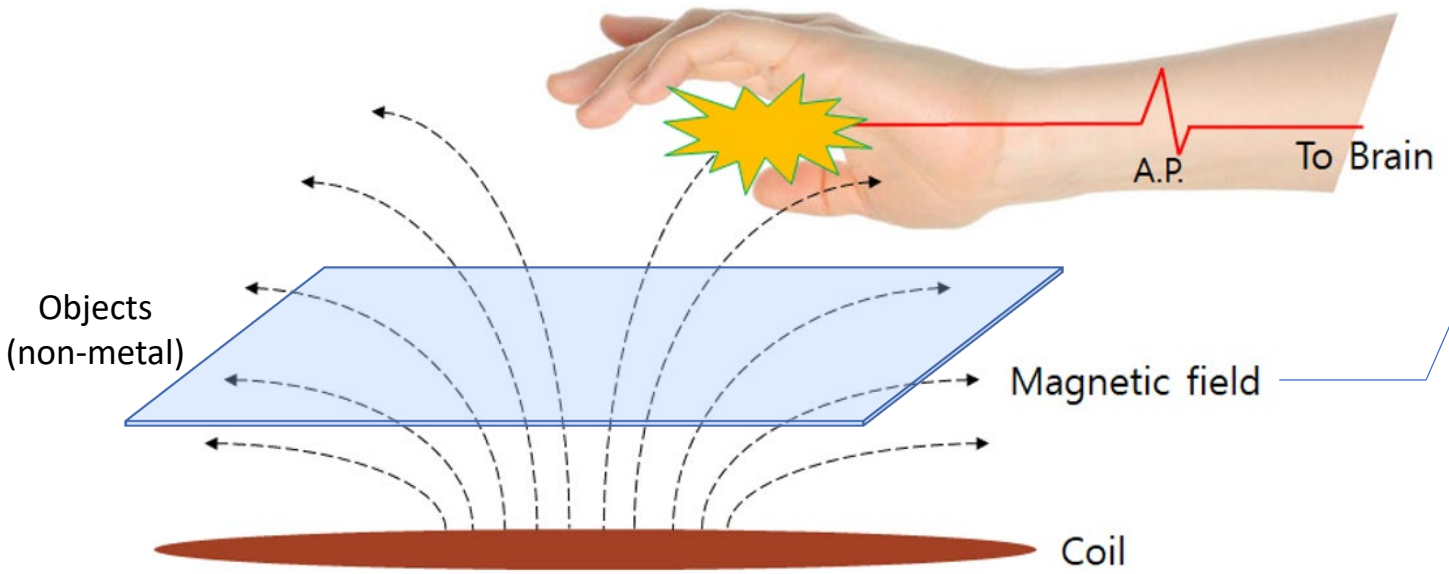
Simulation procedure using ANSYS Workbench



2D and 3D geometry for coil simulation

- Material : copper
- Specific resistance : 1.69×10-2 [Ω/m]
- Specific heat 0.0924 [Cal/g × ℃],
- Number of turns : 28

Method – Related eqatuions for generating time-varying magnetic field



Schematic diagram of tactile sensation induced by magnetic field

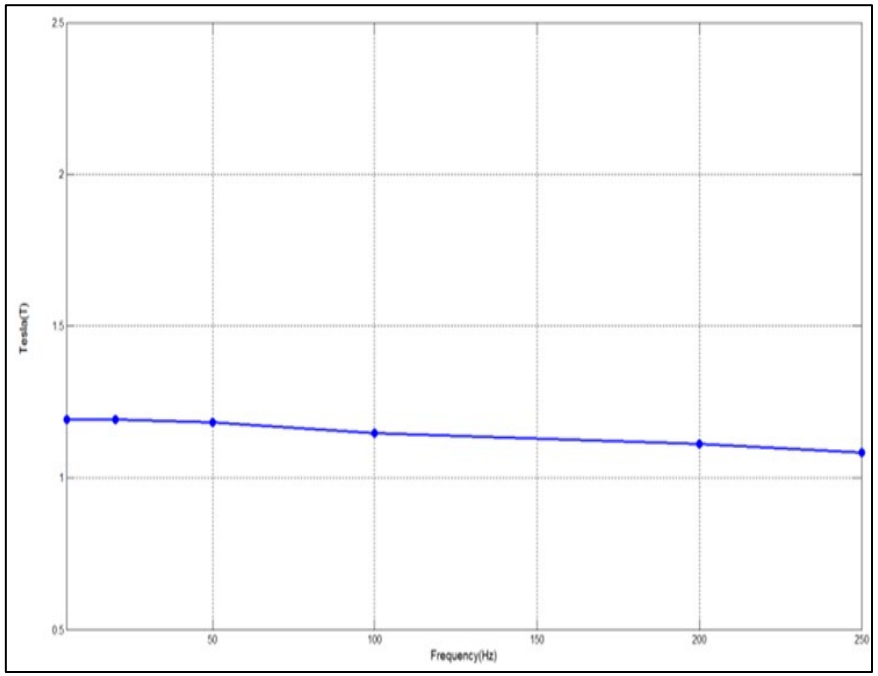
$$\nabla \times E = -\frac{\partial B}{\partial t}$$

$$E = -\frac{\mu_0 N I}{4\pi} \int \frac{1}{R} dl$$

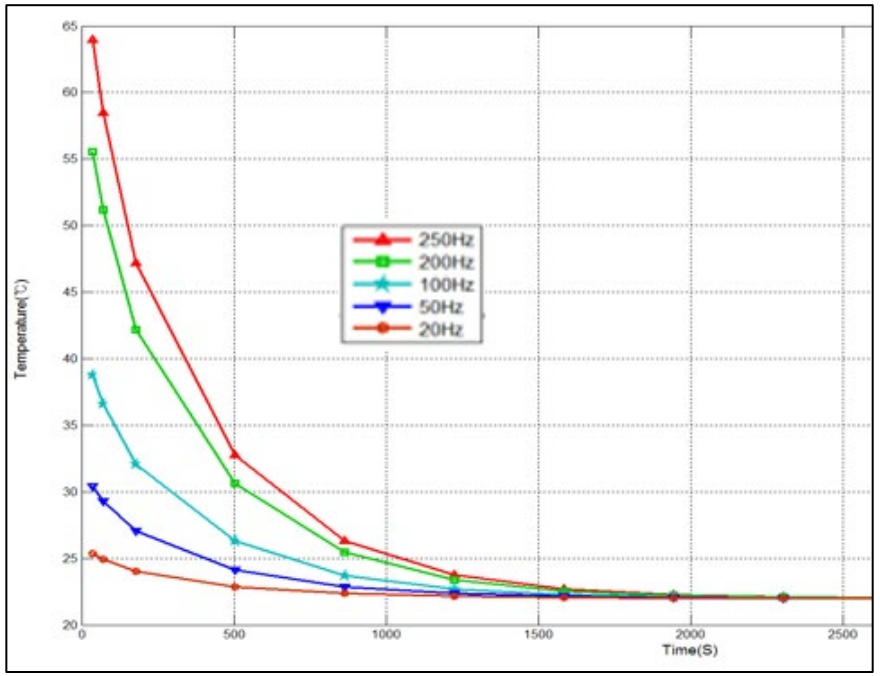
$$H = \frac{\in}{2r} \quad [\frac{AT}{m}]$$

$$H = \int dH = \frac{I}{4\pi} \int \frac{dl sin\theta}{r^2} \quad [\frac{AT}{m}]$$

Results – Magneric field density and Heat dissipation



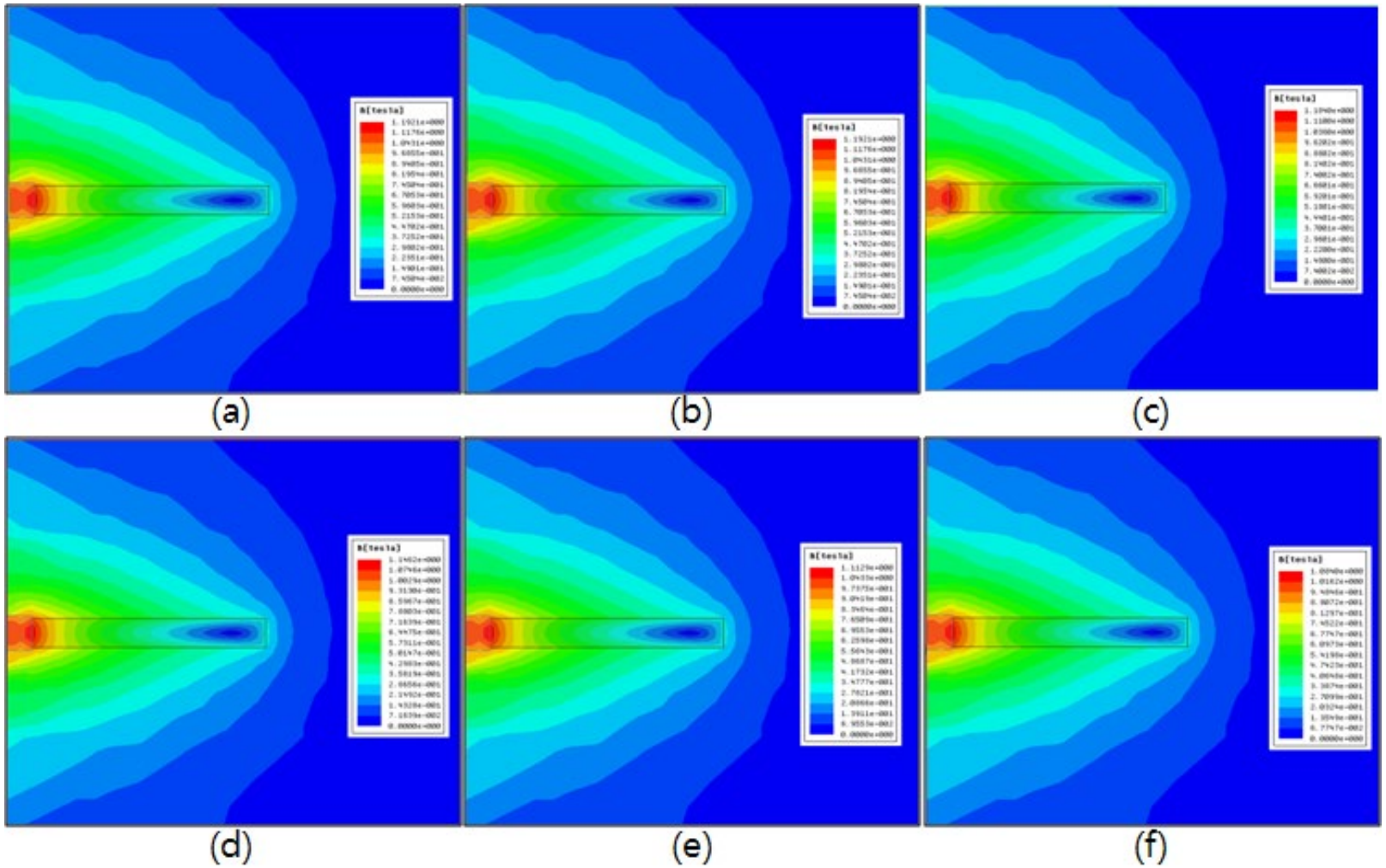
(a)



(b)

Simulation results for circular-coil according to frequencis from 20 Hz to 250 Hz.
(a) Magnetic field density (b) Heat dissipation profile.

Results – Magnetic field map



Simulation results for circular-coil according to frequencis from 20 Hz to 250 Hz for 10 minutes.
(a) 20 Hz, (b) 50 Hz, (c) 100 Hz, (d) 150 Hz (e) 200 Hz (f) 250 Hz.

Conclusion

- Changes in magnetic field pattern and temperature according to the application of pulsed power to the magnetic field generating coil was confirmed.
- The change in the density and field pattern of the magnetic field was small according to the frequency in the range of 5 to 250 Hz.
- In the case of temperature, the maximum rose about 33.1℃.
- It was confirmed that the coil of the proposed shape had a small difference between low frequency and high frequency, so that it was possible to induce a tactile sensation with constant strength and strength even when used for a long time.