

- Infinitely permeable core
- Copper strands
- Air
- Excitation coil (Field)

We have two magnetic fields on the strands:

1. Radial Flux
2. Tangential Flux



The Impact of the Radial and Tangential Flux Components

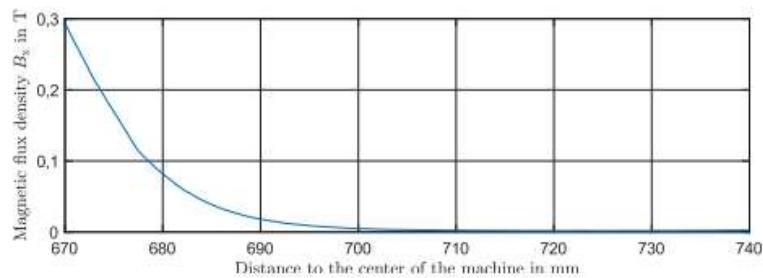
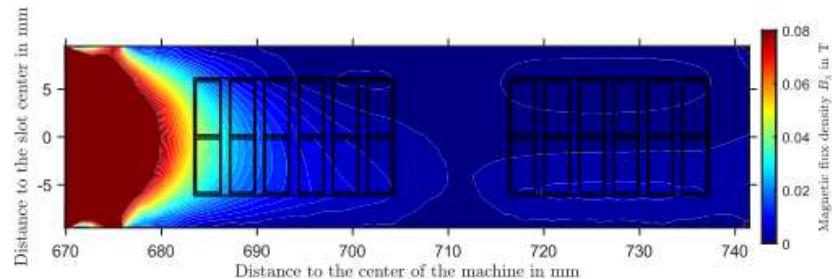


FIGURE 4. Radial component of the flux density along the slot length.

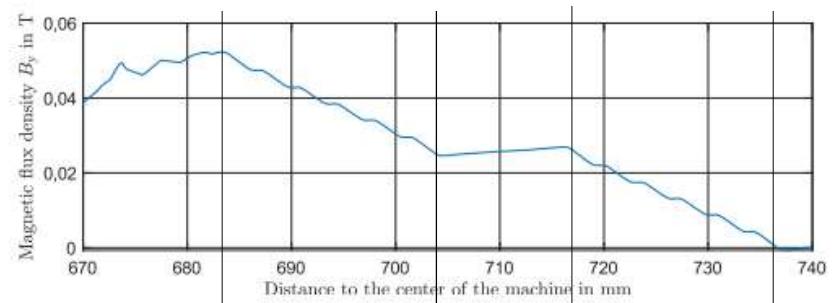
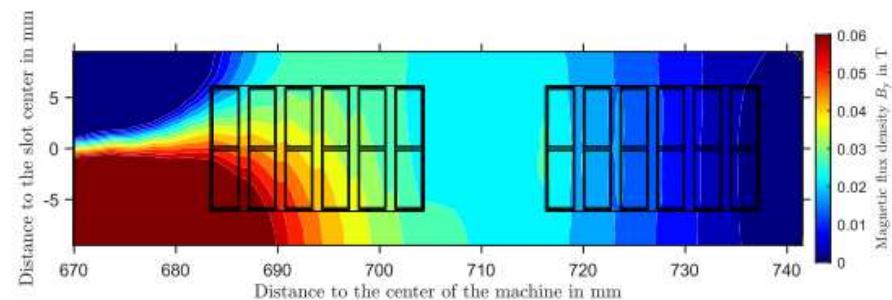


FIGURE 5. Tangential component of the flux density in the slot.

↓ Starting ↓ Ending ↓ Starting ↓ Ending
 Starting first first first first first first
 first winding winding winding winding winding winding

M. W. Meiswinkel, A. Ebrahimi, C. Wohlers and T. Neschitsch, "Transient Roebel Bar Force Calculation in Large Salient-Pole Synchronous Machines," in IEEE Access, vol. 9, pp. 2266-2273, 2021, doi: 10.1109/ACCESS.2020.3046789.

The Radial Flux Component

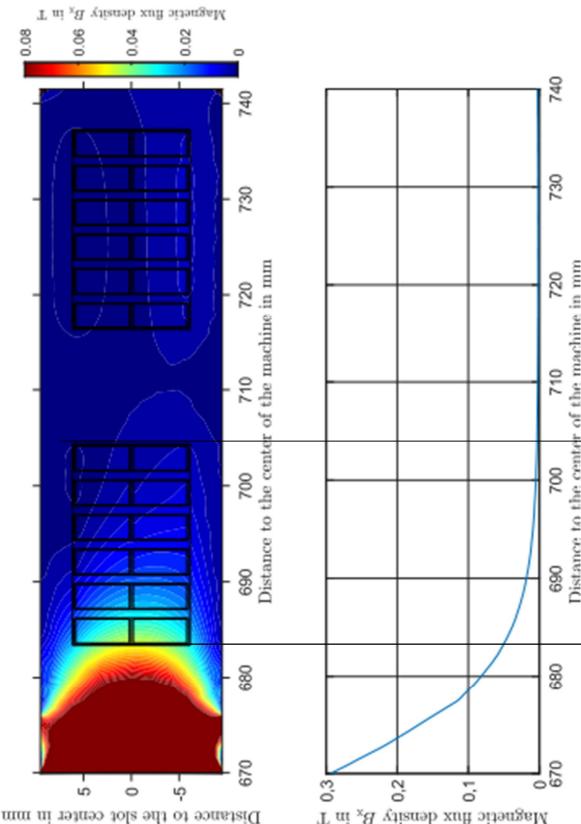
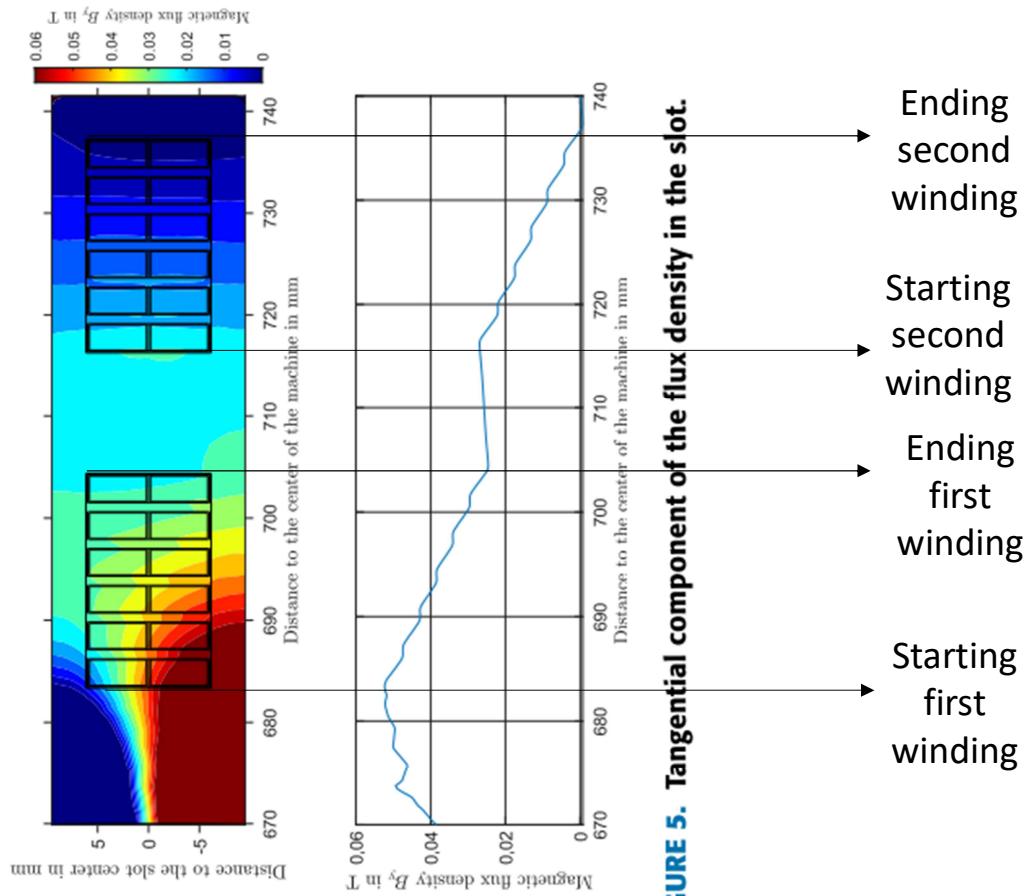


FIGURE 4. Radial component of the flux density along the slot length.

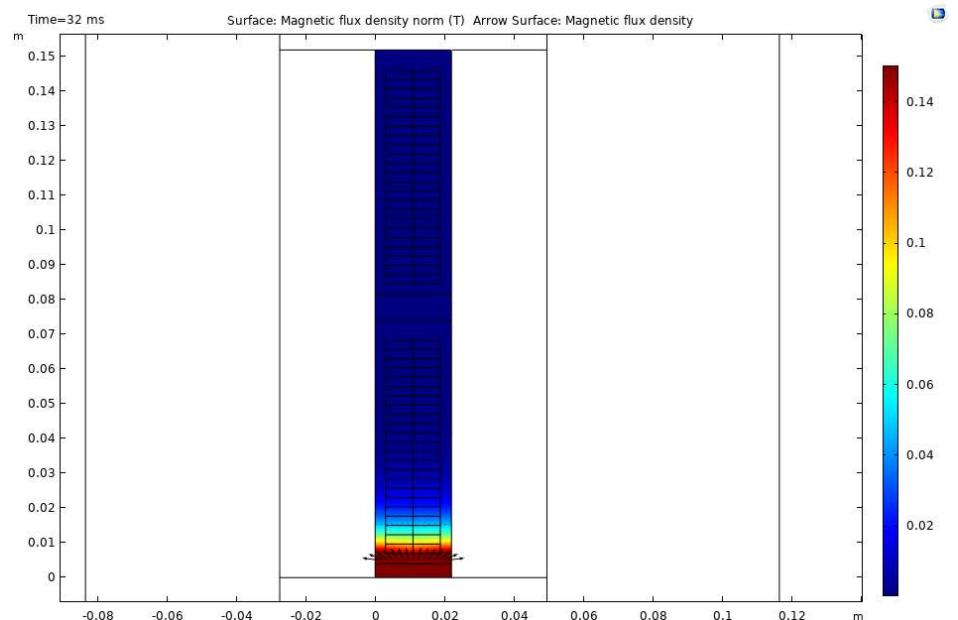
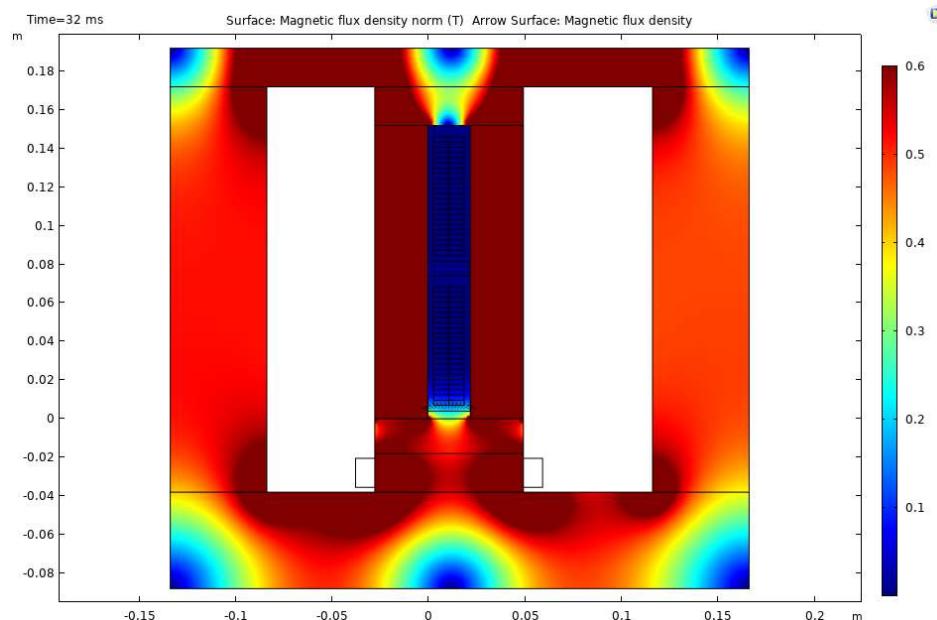
- Radial flux is stemmed from the field (rotor).
- It diminishes while moving away the airgap. ($B \propto \frac{1}{r^2}$)
- In double layer windings, only the close one to the airgap is affected.
- The effect of the flux can be ignored in the winding far away from the airgap.

The Tangential Flux

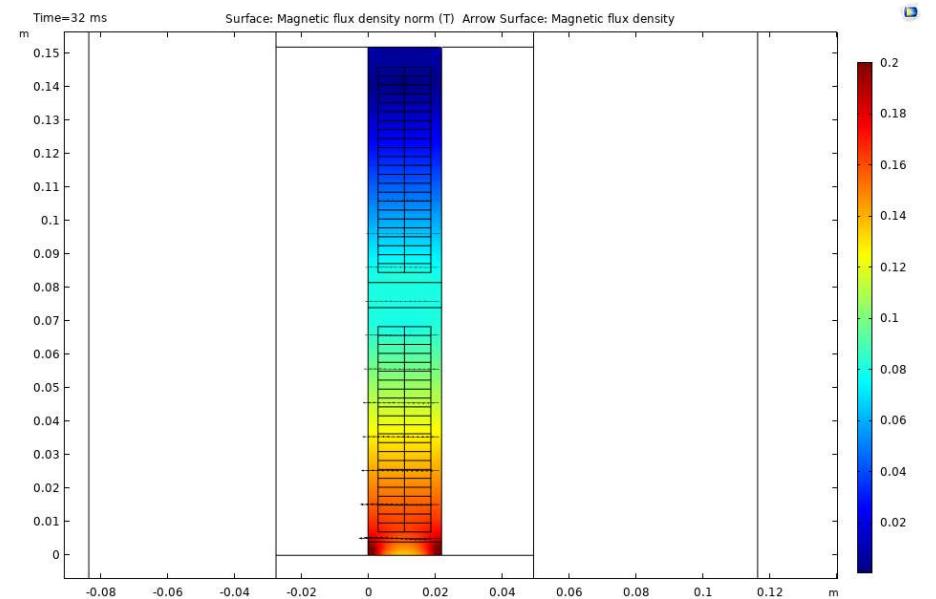
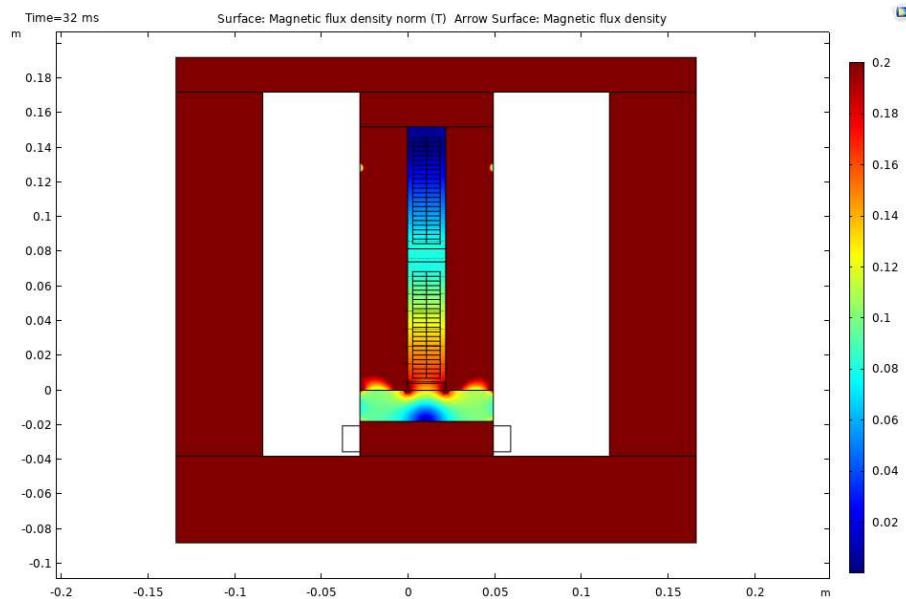


- Tangential flux is stemmed from the strands themselves.
- It diminishes while moving away the airgap. (Triangle shape B field, obeying $Hdl = NI$)

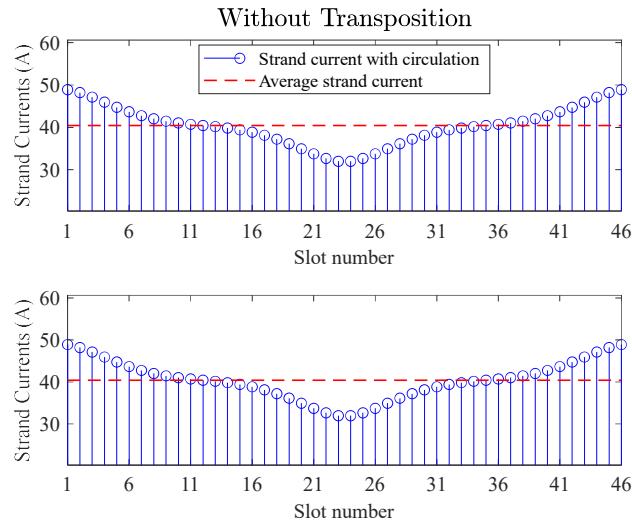
Radial Flux on the Strands



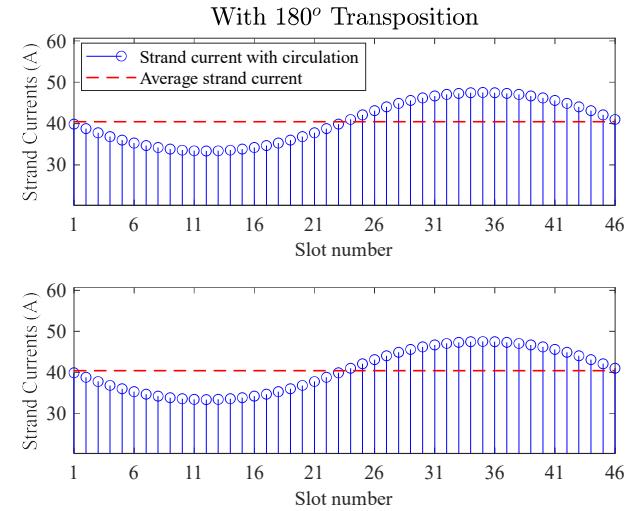
Tangential Flux on the Strands



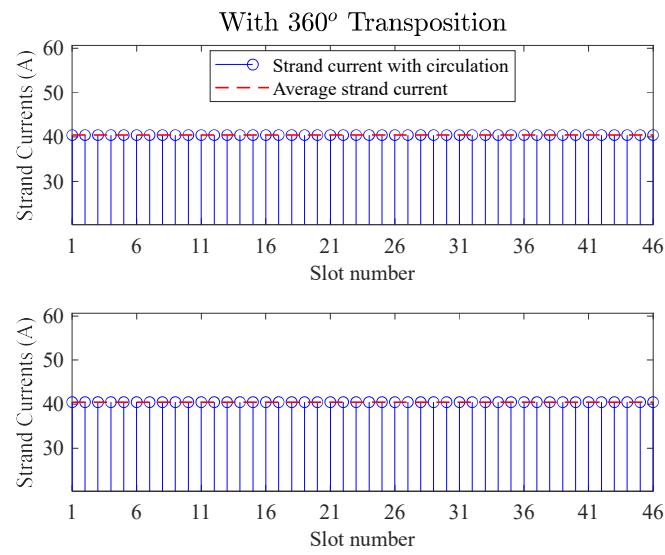
Circulating Currents (Tangential Flux)



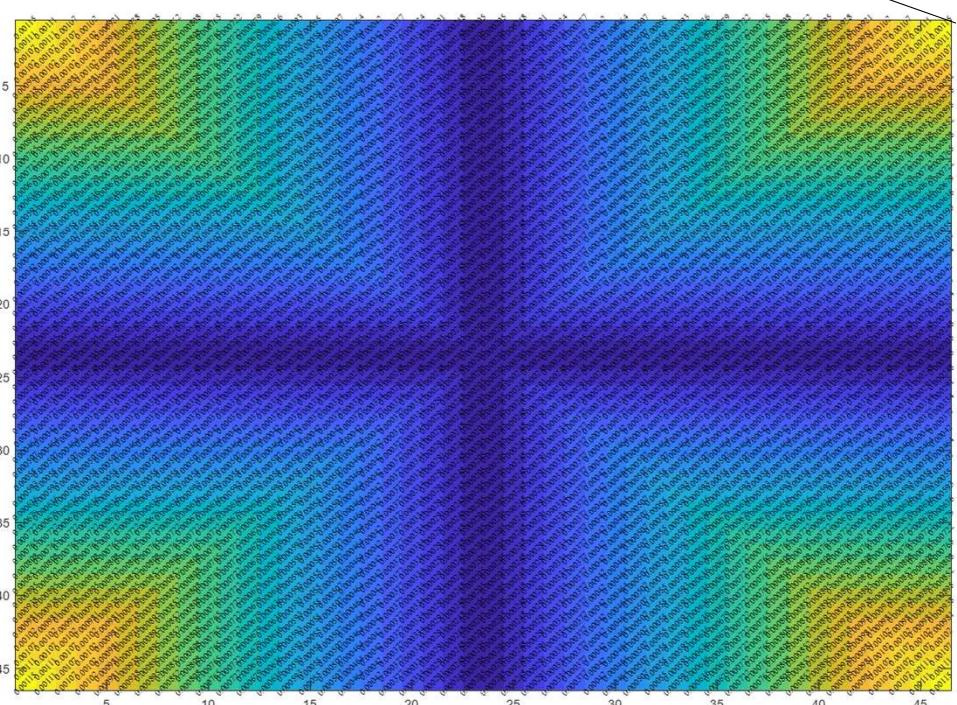
$$100 \frac{r_{ac}}{r_{dc}} = 101.6782$$



$$100 \frac{r_{ac}}{r_{dc}} = 101.8565$$

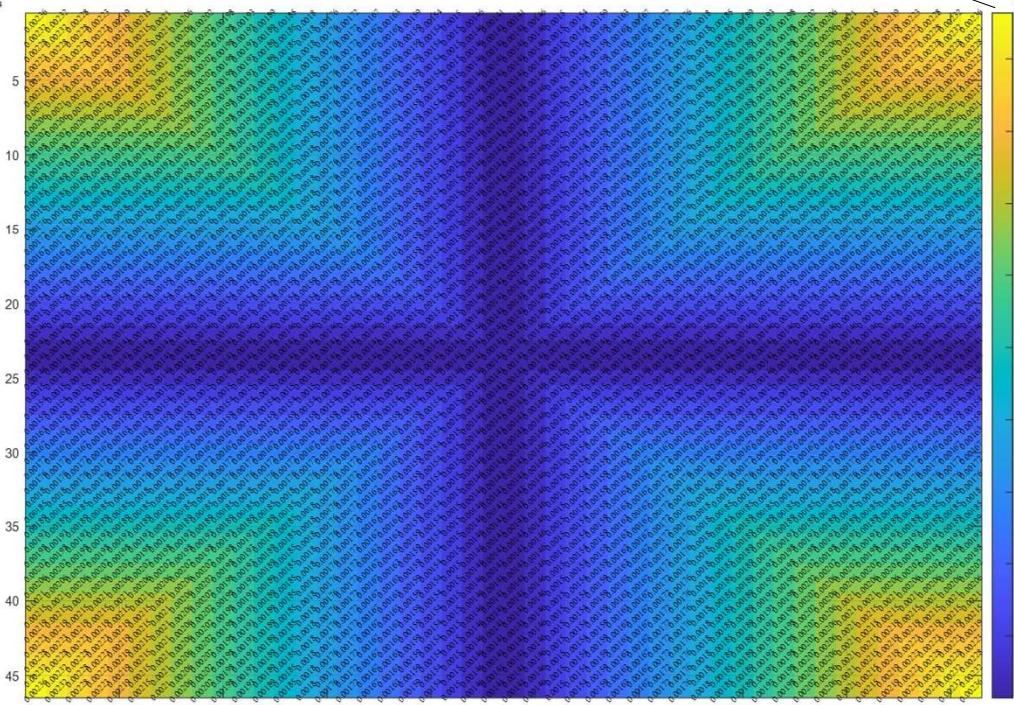


Slot Number



Max 1.2 mH

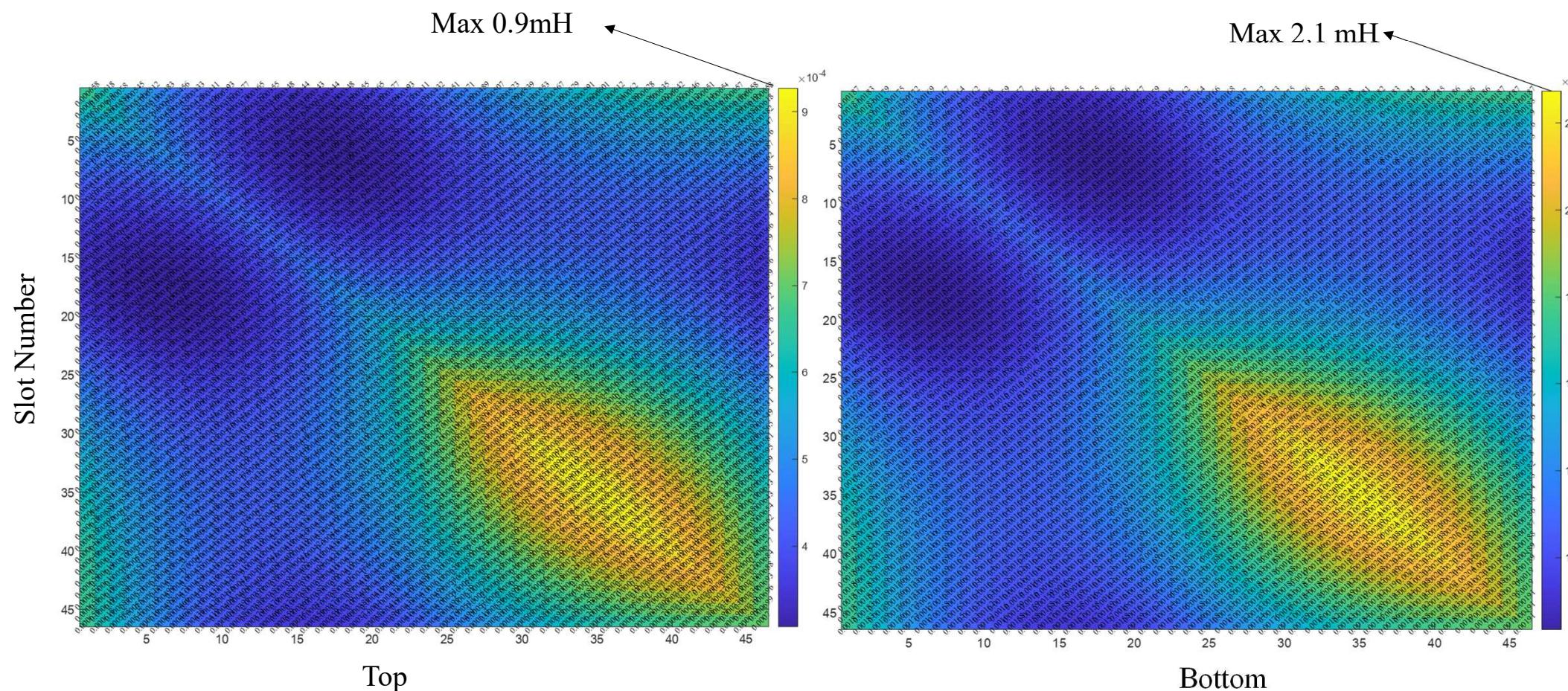
Top



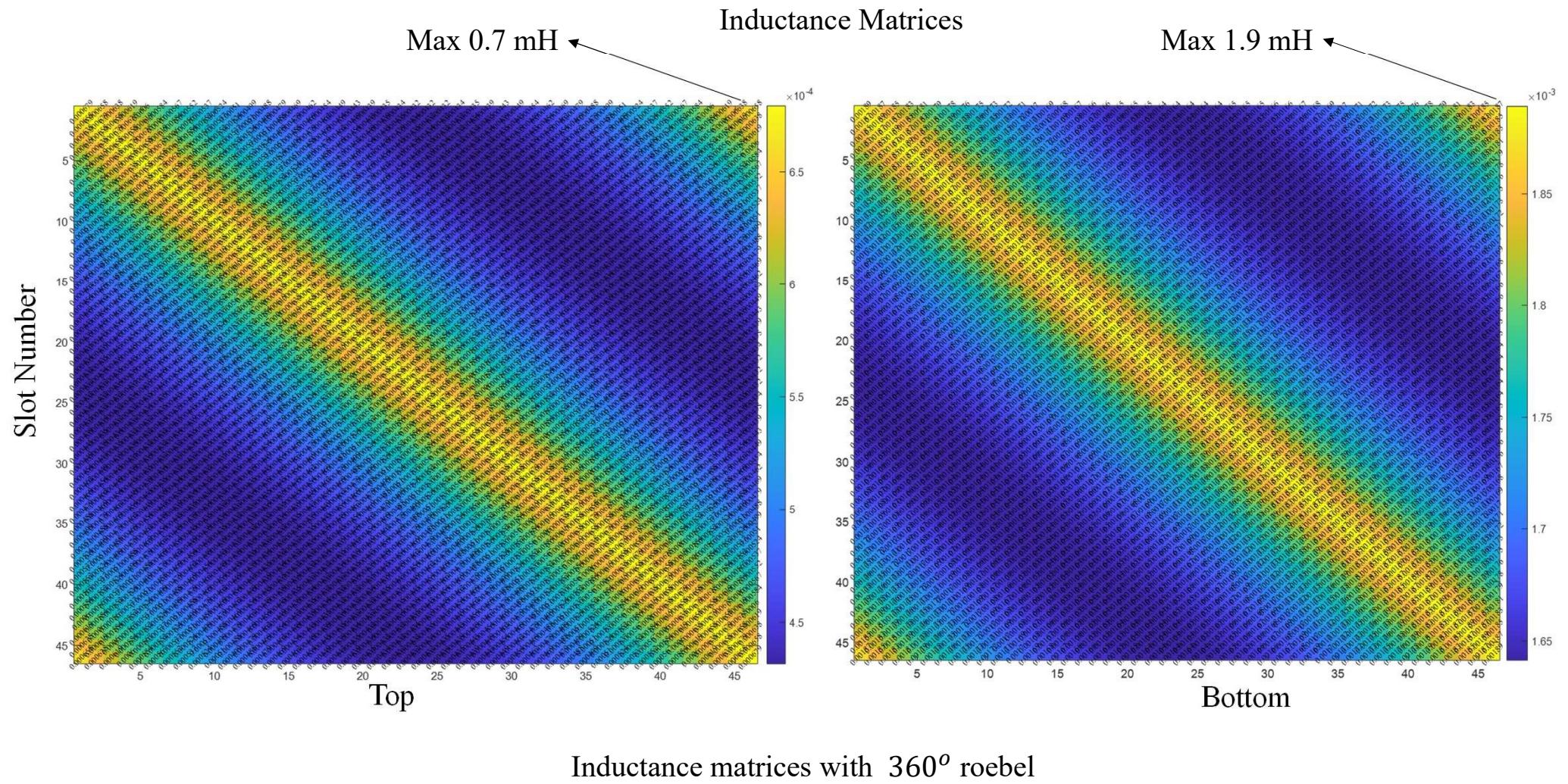
Max 2.4 mH

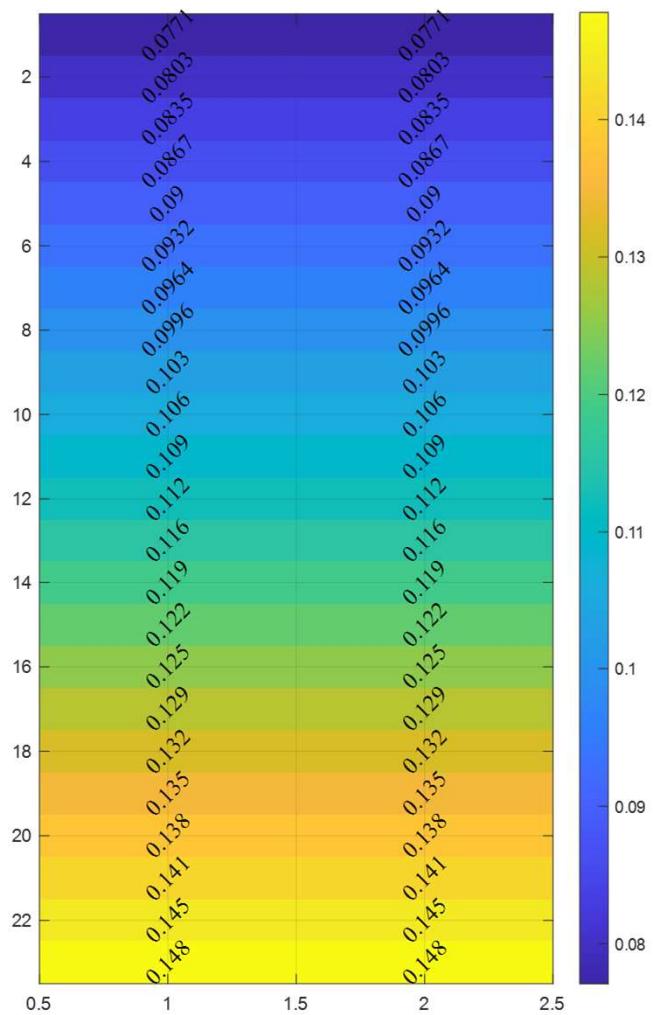
Bottom

Inductance matrices without roebel



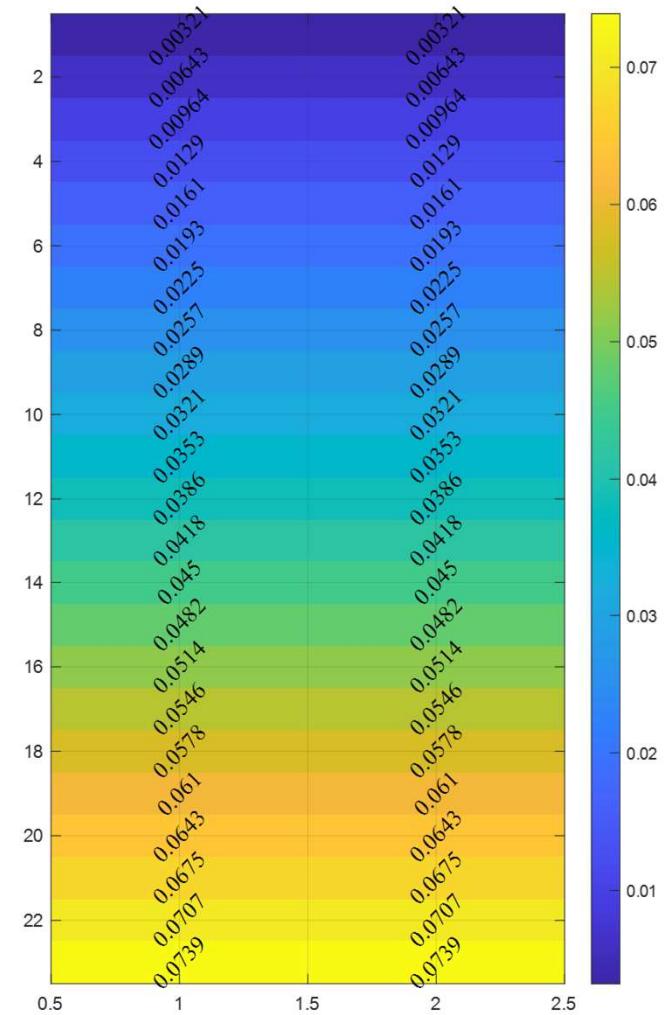
Inductance matrices with 180° roebel



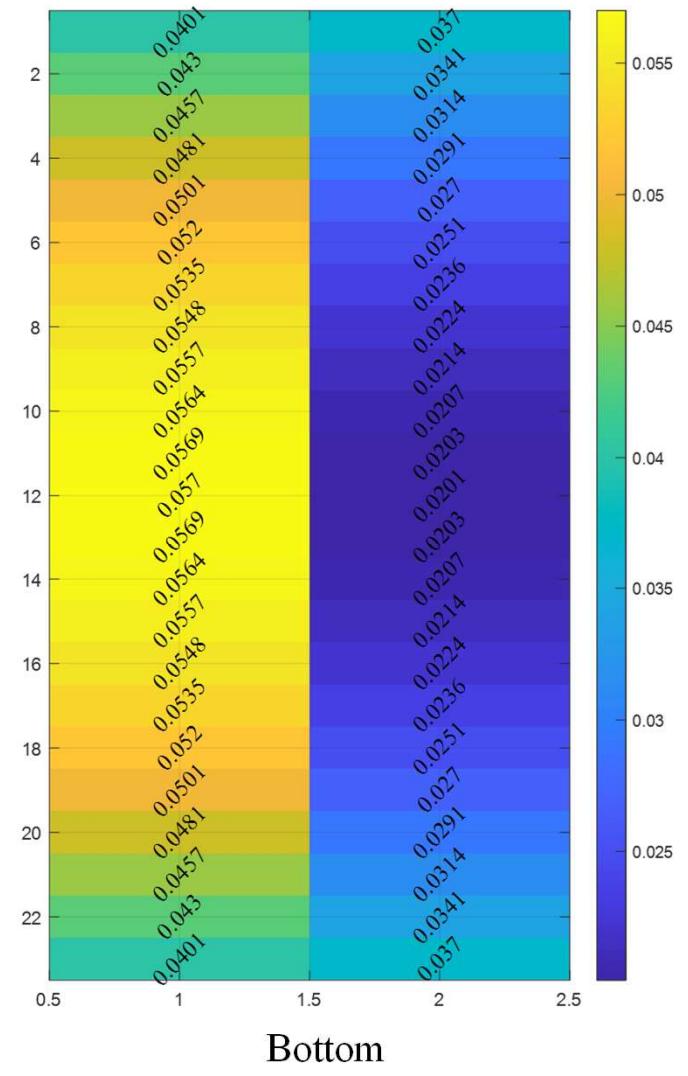
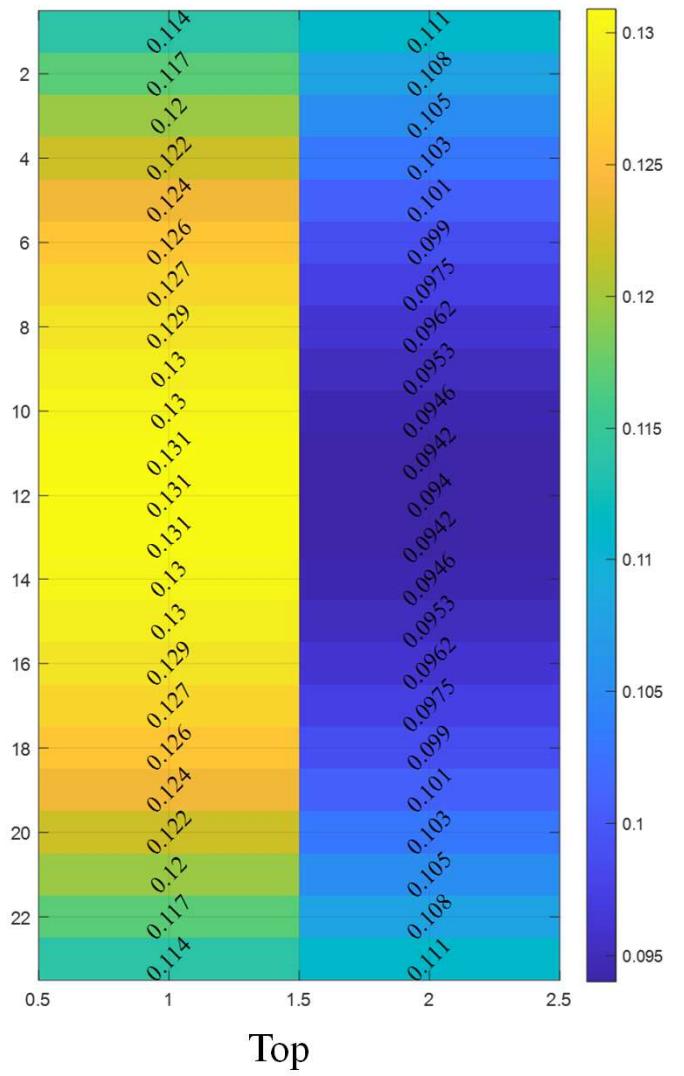


Top

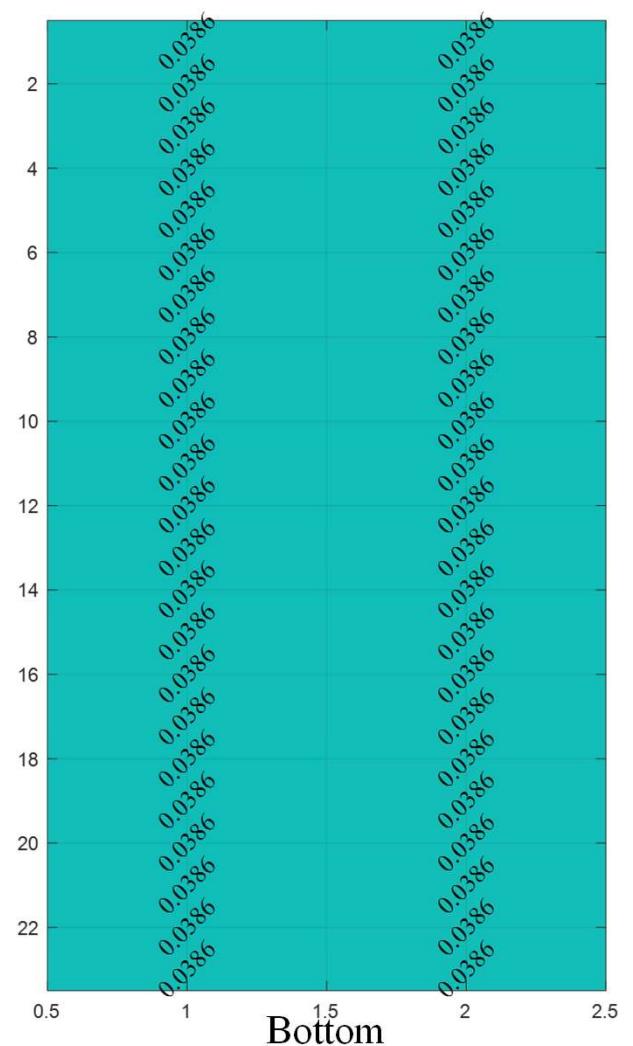
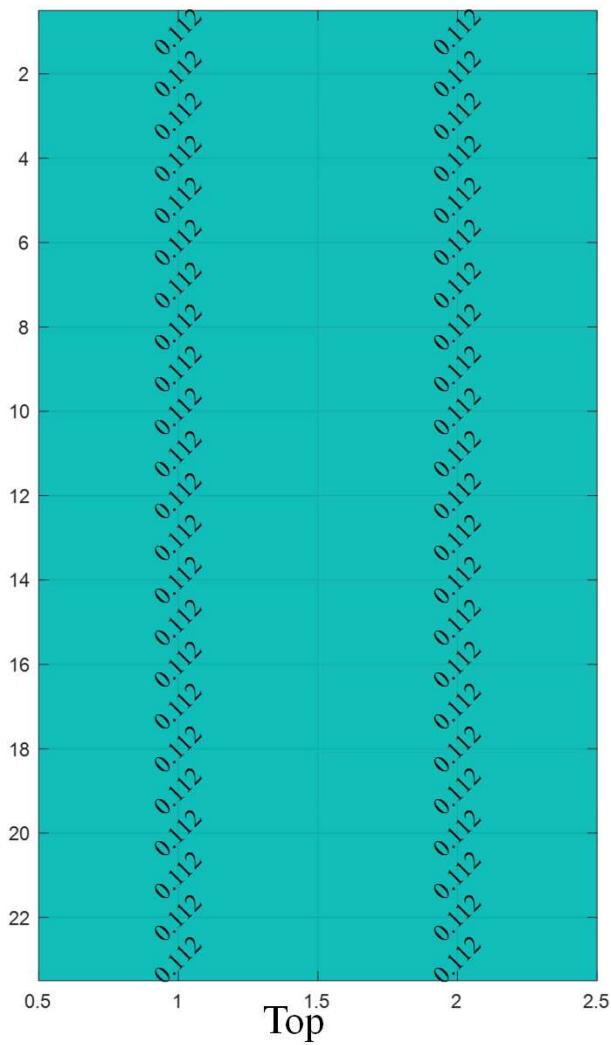
Induced voltage from tangential fluxes without roebel



Bottom



Induced voltage from tangential fluxes with 180° roebel



Induced voltage from tangential fluxes with 360° roebel