Question 3

Q: How to calculate the amount of electric charge that has been stored on an electrode?

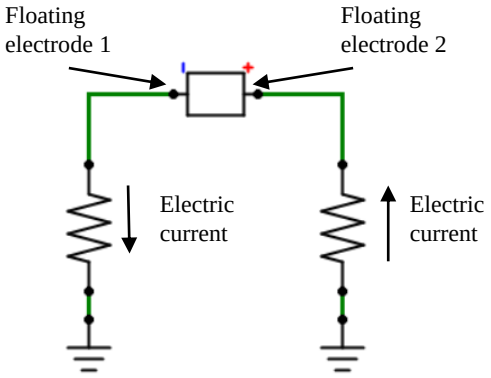
A: If [Specify Electric Potential] is set to the electrode, the stored electric charge will be displayed on the table.

If [Floating Electrode] is set to the electrode, by selecting [Add a resistor across to ground] and specifying the resistance, an electric charge can move freely, which means an electric current can flow. This allows you to calculate the charge stored at the floating electrode.

Please refer to the next slides.

Charge Stored at Electrode(1/3)

- The charge on the boundary with a specified electric potential is displayed on the table.
- The charge of an electrode with no electric potential specified, that is a floating electrode, is calculated as its electric potential being constant. As the numbers of positive and negative charges are equal, the total charge will become zero. In the table, the charge of zero is displayed.
- As shown on the right, by connecting an external resistor to the floating electrode, an electric charge can move freely, which means an electric current can flow. This allows you to calculate the charge stored at the floating electrode.



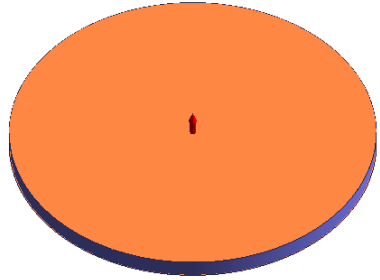
Charge Stored at Electrode(2/3)

Example: Charge stored at the electrode of a piezoelectric disc when pressure is applied from above and below to it.

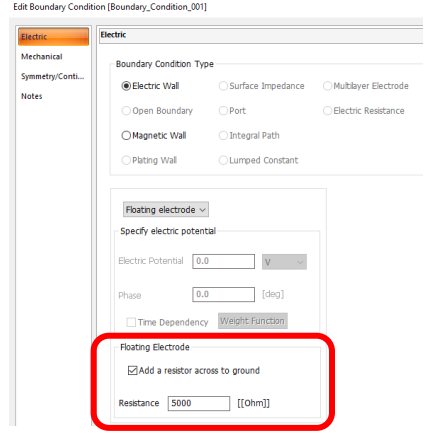
- Piezo-Harmonic Analysis
  Frequency: 1e3 [Hz]
- Disc Size
  Radius: 10 [mm], Thickness: 1 [mm]
- Material
  Piezoelectric: P-4 (Available from the material DB)
- Polarization Axis
  Positive Z direction
- Boundary Condition

Set floating electrode boundaries to the upper and lower faces discretely and connect a resistor of 5000 Ω in series from each electrode to the ground. Set pressure of -1 [N/m2] to the upper face and set fixed displacement in the Z direction to the lower face.

Upper face: Floating electrode 1



Lower face: Floating electrode 2



Charge Stored at Electrode(3/3)

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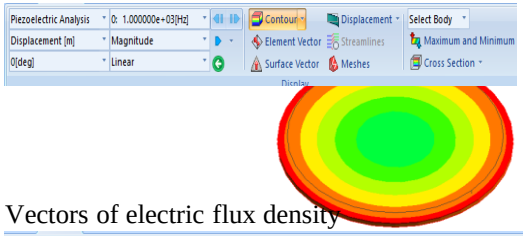
Example: Charge stored at the electrode of a piezoelectric disc when pressure is applied from above and below to it.

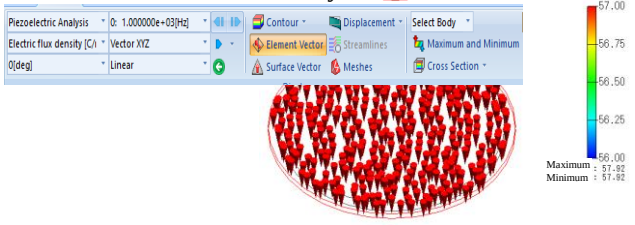
- The displacement contour indicates deformation is uniform.
- The charge of the floating electrode, Q, is 1.8e-14 [C] from the table.
- The electric flux density vectors have a uniform distribution, 57e-12 [C/m2]. The charge can be calculated by integrating electric flux density. The area of the disc is S=0.01*0.01*3.14=3.14e-2 [m2]. Then the charge is Q=57e-12*3.14e-2=1.79e-14 [C]. This value closely coincides with the value in the table, 1.8e-14 [C].
- From the difference in electric potential between floating electrodes, the voltage generated on the piezoelectric disc can be calculated:

  Voltage=+5.68e-7 [V]-(-5.68e-7 [V])=11.36e-7 [V]=11.4 [uV].

Contour of displacement



Vectors of electric flux density



Table

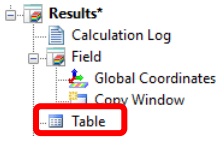


Table (Charge)

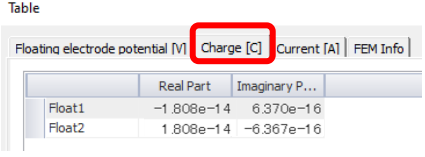


Table (Floating electrode potential)