

# **Tutorial for Calculation of Reflectance, Transmittance and Absorptance**

***with step-by-step instructions***

Ver: 1.1 (2025-09-04)



ComPhysics

# Symbols and abbreviations used in E2M

| Symbol          | Meaning                                                                          |
|-----------------|----------------------------------------------------------------------------------|
| $L\#$           | Layer index                                                                      |
| T.              | Thickness                                                                        |
| $\lambda$       | Wavelength                                                                       |
| $\mu'$          | Real part of relative permeability                                               |
| $\mu''$         | Imaginary part of relative permeability                                          |
| $\varepsilon'$  | Real part of relative permittivity                                               |
| $\varepsilon''$ | Imaginary part of relative permittivity                                          |
| $\tilde{k}$     | Normalized wave vector                                                           |
| GX#             | G: Group index<br>X: seperator meaning times<br>#: Repetition num. for the group |
| $\theta$        | The azimuthal angle                                                              |
| $\varphi$       | The polar angle                                                                  |
| TE              | Transverse Electric                                                              |
| TM              | Transverse Magnetic                                                              |
| R               | Reflectance                                                                      |
| T               | Transmittance                                                                    |
| A               | Absorptance ( $R + T + A = 1$ )                                                  |
| $\alpha$        | Thickness of a period                                                            |
| C               | speed of light                                                                   |



In this tutorial, step-by-step instructions for recalculating Fig. 7.8 of reference 1) below are offered. By performing these steps, you will learn how to extract reflectance, transmittance, absorptance, and field distribution by utilizing E2M.

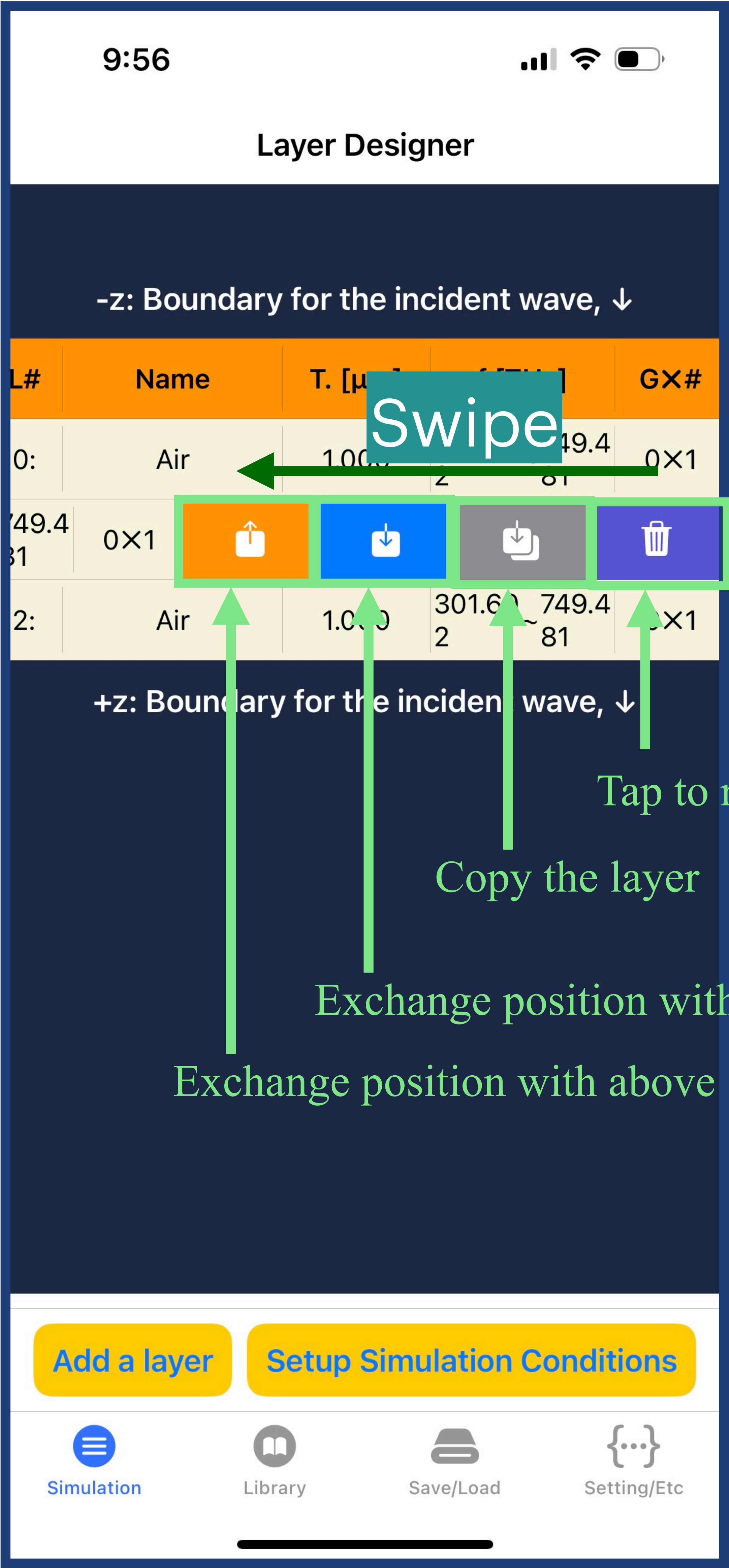
This tutorial requires creating four layers to recalculate the reference selected. Therefore, this tutorial cannot be followed up with freeware mode. Since we offer a 1-week free usage period for any standard subscription, you may use this offer to follow this tutorial up.

On the next page, this tutorial will finally start.

1) Yeh, Pochi. Optical Waves in Layered Media. New York: Wiley-Interscience, 1988.

(Optional steps for users followed in performing other tutorials)

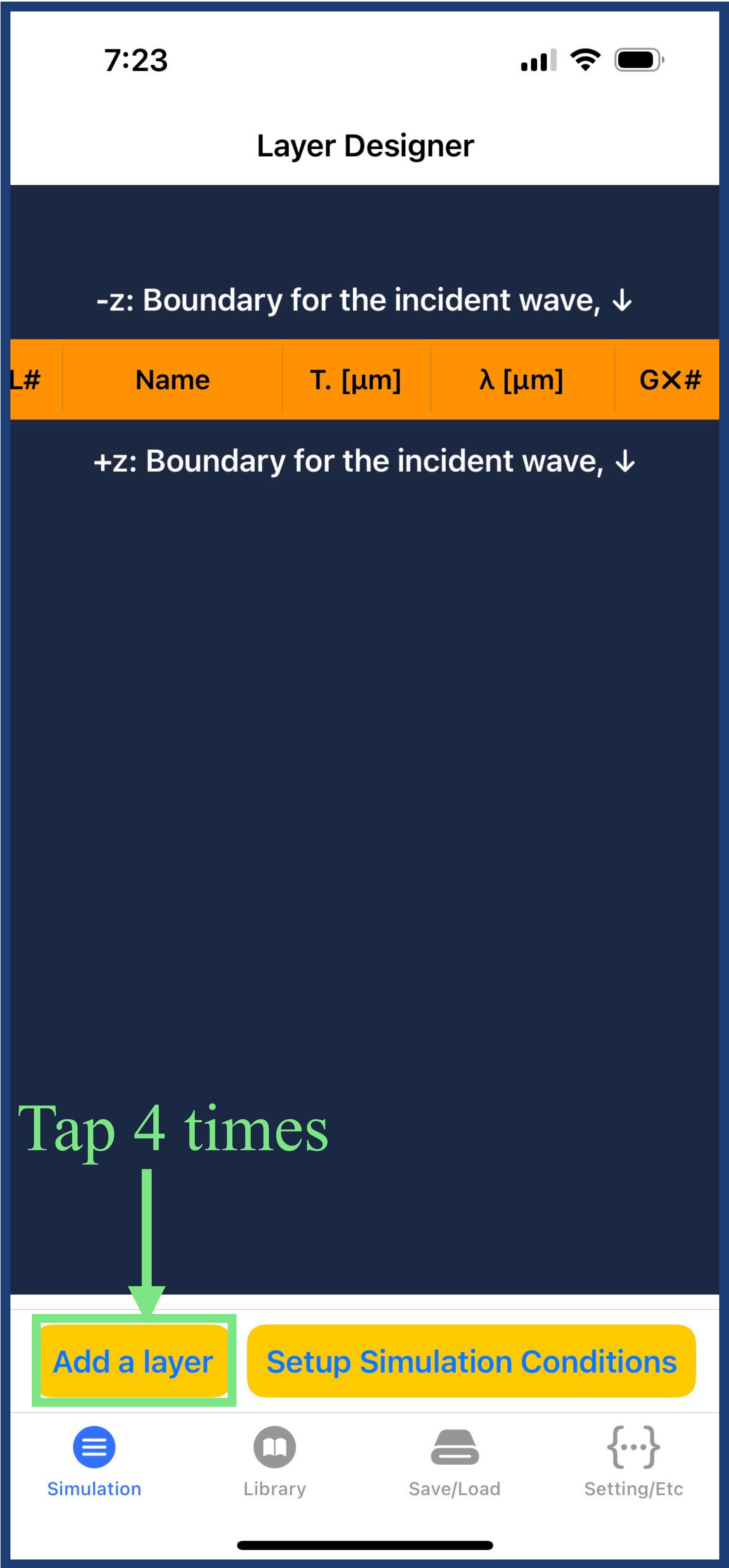
A. Users can remove a layer by swiping from right to left and tapping the “trash” icon.



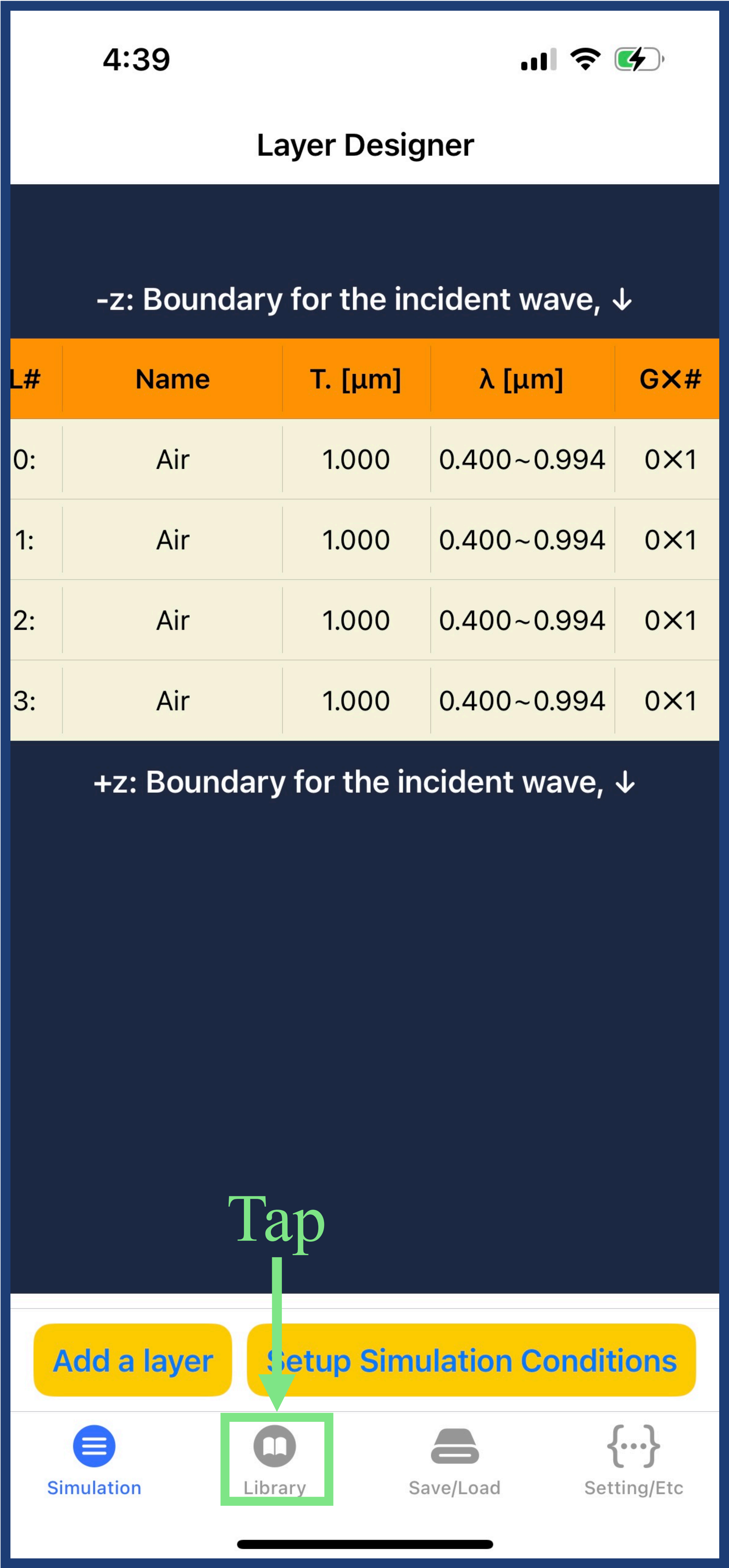
Try swiping to other types of layers on other pages.



1. Tap “Add a layer” button four times to create four layers.  
Boundary must maintain “-z: Boundary for the incident wave, ↓” and “+z: Boundary for the incident wave, ↓”.

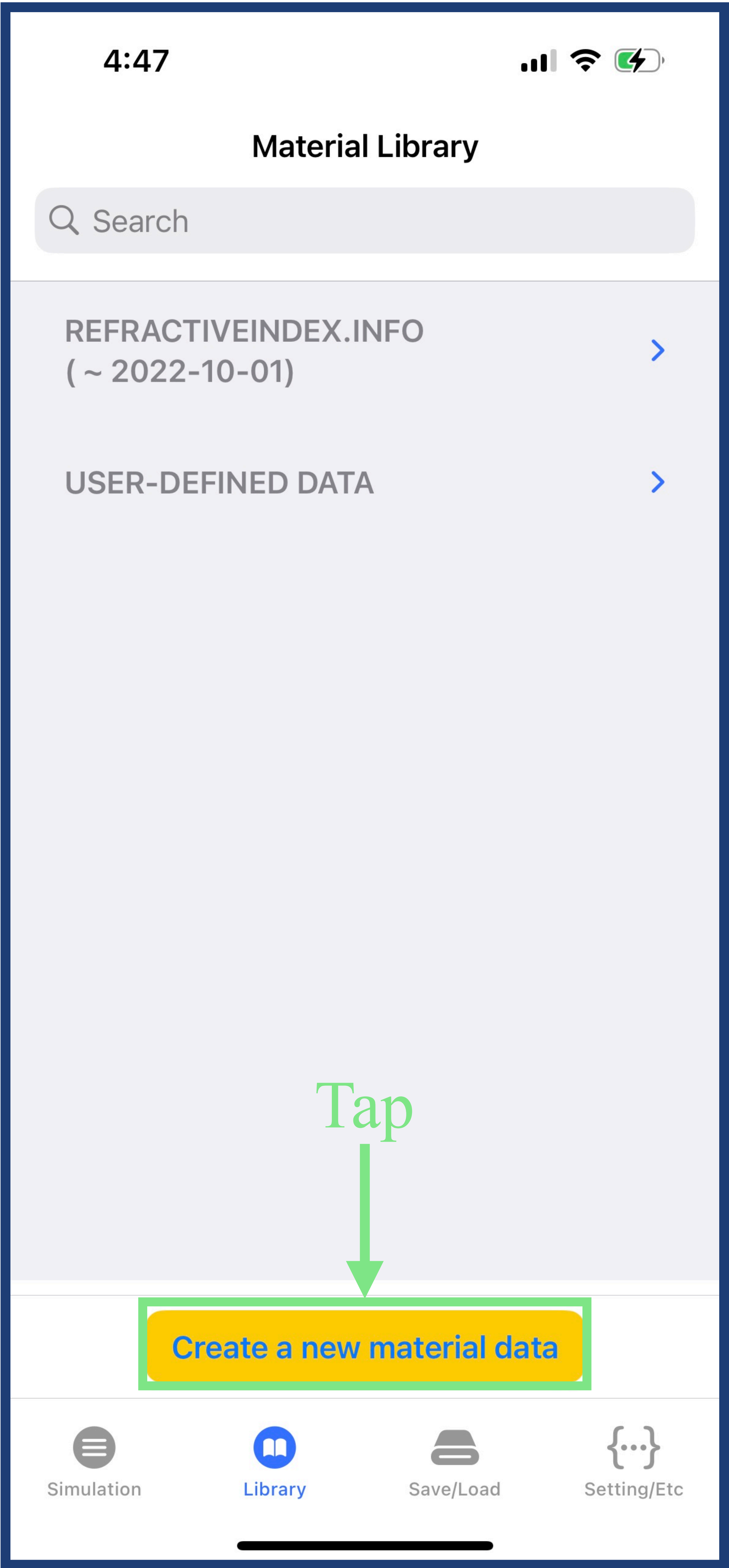


2. We need to create three new user-defined materials before inputting each layer's information. Tap the “Library” icon.





3. Tap “Create a new material data” button.





4. We are going to create three constant  $\epsilon_r$  whose values are maintained for the frequency range of 0.1 THz and 1200 THz. Since the current table shows wavelength notation, let us change this to the frequency notation. Tap the “Setting/Etc” icon.

4:50

< Back

Name: Vacuum

Info.: Input description for this material data.

| # | $\lambda$ [ $\mu\text{m}$ ] | $\mu'$   | $\mu''$  | $\epsilon'$ | $\epsilon''$ |
|---|-----------------------------|----------|----------|-------------|--------------|
| 0 | 1.00e-05                    | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |
| 1 | 1.00e+05                    | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |

$\lambda$  [ $\mu\text{m}$ ] = 1.0

$\mu' = 1.0$  ,  $\mu'' = 0.0$

$\epsilon' = 1.0$  ,  $\epsilon'' = 0.0$

Insert below the last layer

Save

Plot

Simulation

Library

Save/Load

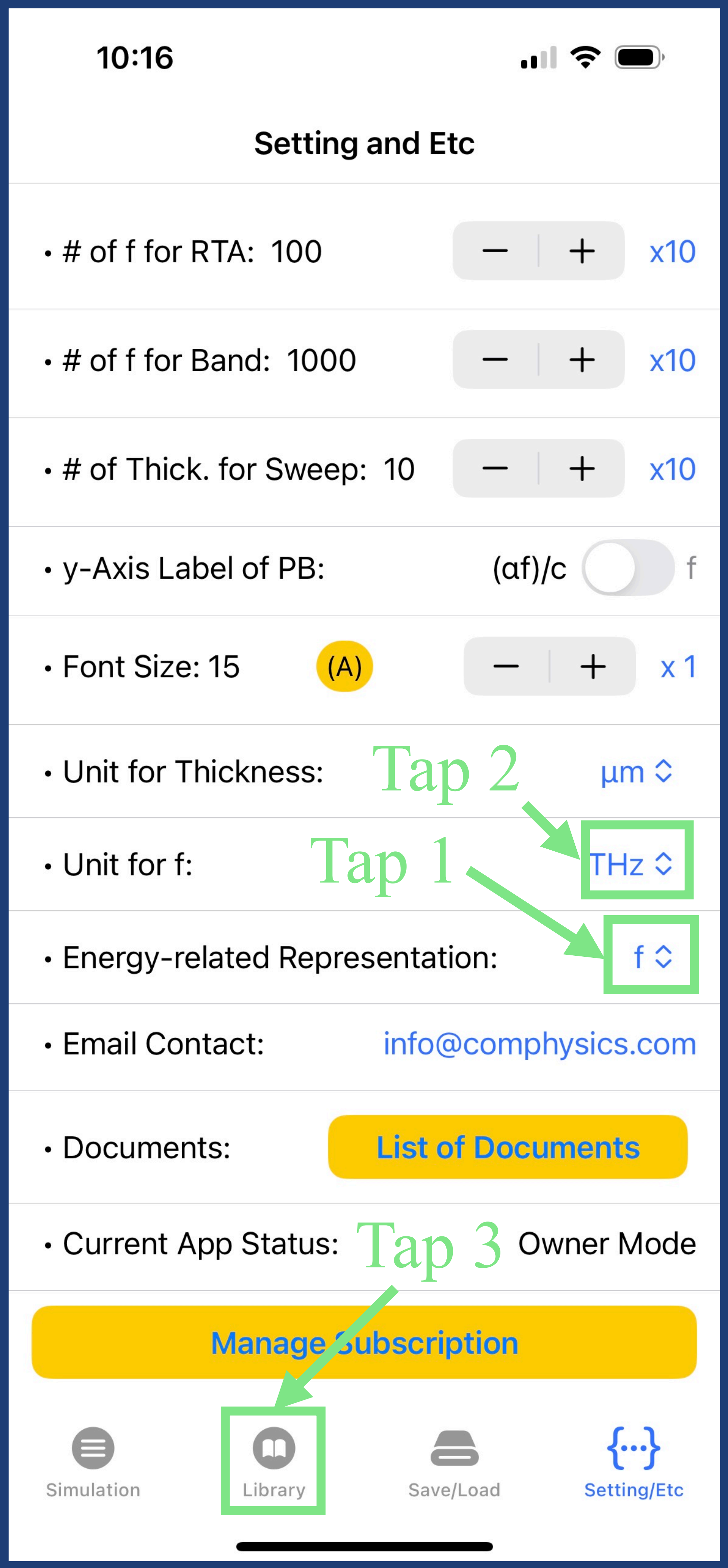
Setting/Etc

Tap

8



5. First, tap “Energy-related Representation” and then tap “f”. Here, f means frequency. Second, tap “Unit for f” and tap “THz”. Then, tap “Library” icon to go back.



6. We can see the changed symbol and unit from  $\lambda$  [ $\mu\text{m}$ ] to  $f$  [THz]. Tap #0 row of the table.

5:00

< Back

Name: Vacuum

Info.: Input description for this material data.

| # | f [THz]  | $\mu'$   | $\mu''$  | $\epsilon'$ | $\epsilon''$ |
|---|----------|----------|----------|-------------|--------------|
| 0 | 3.00e+07 | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |
| 1 | 3.00e-03 | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |

Tap

f [THz] = 299.792458

$\mu' = 1.0$  ,  $\mu'' = 0.0$

$\epsilon' = 1.0$  ,  $\epsilon'' = 0.0$

Insert below the last layer

Save

Plot

Simulation

Library

Save/Load

Setting/Etc

10



7. Tap the field f and input 1200.  
Then, tap “Apply” button to  
apply the changed value.

5:54

Tap 1

< Back

f [THz] 1200

$\mu' = 1.0$  ,  $\mu'' = 0.0$

$\epsilon' = 1.0$  ,  $\epsilon'' = 0.0$

Apply

Tap 2

Simulation Library Save/Load Setting/Etc



8. We can confirm the changed f value in the #0 row of the table. Tap the #1 row of the table.

5:58

< Back

Name: Vacuum

Info.: Input description for this material data.

| # | f [THz]  | $\mu'$   | $\mu''$  | $\epsilon'$ | $\epsilon''$ |
|---|----------|----------|----------|-------------|--------------|
| 0 | 1.20e+03 | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |
| 1 | 3.00e-03 | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |

Tap

f [THz] = 299.792458

$\mu' = 1.0$  ,  $\mu'' = 0.0$

$\epsilon' = 1.0$  ,  $\epsilon'' = 0.0$

Insert below the last layer

Save

Plot

Simulation

Library

Save/Load

Setting/Etc



9. Input 0.1 after tapping f field.  
Then, tap “Apply” button to go  
back.

The screenshot shows a mobile application interface with a status bar at the top displaying the time 5:59, signal strength, Wi-Fi, and battery icons. The main content area has a blue header with a back arrow and the text "Back". Below this, there is a label "f [THz]" followed by a text input field containing the value "0.1". A green arrow labeled "Tap 1" points to this input field. Below the frequency field, there are two rows of input fields for material properties. The first row shows  $\mu' =$  followed by a field with "1.0", then a comma,  $\mu'' =$  followed by a field with "0.0". The second row shows  $\epsilon' =$  followed by a field with "1.0", then a comma,  $\epsilon'' =$  followed by a field with "0.0". Below these fields is a large yellow button with the text "Apply" in blue. A green arrow labeled "Tap 2" points to this button. At the bottom of the screen is a navigation bar with four icons and labels: "Simulation" (hamburger menu icon), "Library" (book icon), "Save/Load" (floppy disk icon), and "Setting/Etc" (three dots in curly braces icon). The "Library" icon and label are highlighted in blue.

5:59

Tap 1

< Back

f [THz] 0.1

$\mu' =$  1.0 ,  $\mu'' =$  0.0

$\epsilon' =$  1.0 ,  $\epsilon'' =$  0.0

Apply

Tap 2

Simulation Library Save/Load Setting/Etc

10. Tap the “Save” button to save all input information. Next, tap the Name field and enter “n=1.5”. Then tap the first row of the table, which is #0.

5:59

Tap 2

Back

Name: Vacuum

Info.: Input description for this material data.

Tap 3

| # | f [THz]  | $\mu'$   | $\mu''$  | $\epsilon'$ | $\epsilon''$ |
|---|----------|----------|----------|-------------|--------------|
| 0 | 1.20e+03 | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |
| 1 | 1.00e-01 | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |

f [THz] = 299.792458

$\mu' = 1.0$  ,  $\mu'' = 0.0$

$\epsilon' = 1.0$  ,  $\epsilon'' = 0.0$

Insert below the last layer

Save

Plot

Simulation

Library

Save/Load

Setting/Etc

Tap 1



11. After tapping  $\epsilon'$  field, input 2.25, which is identical to the  $n=1.5$  with non-magnetic material assumption. Next, tap “Apply” button to go back.

6:20

Tap 1

< Back

f [THz]

$\mu' =$   ,  $\mu'' =$

$\epsilon' =$   ,  $\epsilon'' =$

Apply

Tap 2

Simulation Library Save/Load Setting/Etc



12. Tap the #1 row and change  $\epsilon'$  to 2.25 as before. Tap the “Apply” button after that.

6:25

< Back

Name: 

n=1.5

Info.: 

Input description for this material data.

| # | f [THz]  | $\mu'$   | $\mu''$  | $\epsilon'$ | $\epsilon''$ |
|---|----------|----------|----------|-------------|--------------|
| 0 | 1.20e+03 | 1.00e+00 | 0.00e+00 | 2.25e+00    | 0.00e+00     |
| 1 | 1.00e-01 | 1.00e+00 | 0.00e+00 | 1.00e+00    | 0.00e+00     |

↑ Tap

f [THz] = 

299.792458

$\mu' =$ 

1.0

 $, \mu'' =$ 

0.0

$\epsilon' =$ 

1.0

 $, \epsilon'' =$ 

0.0

Insert below the last layer

Save

Plot

☰

Simulation

📖

Library

💾

Save/Load

{...}

Setting/Etc

13. Tap the “Save” button to save the user-defined material with  $n=1.5$ . Next, tap the Name field and enter “ $n=2.5$ ”. Next, tap the table’s #0 row. After that, change the value of  $\epsilon'$  to 6.25 and tap the “Apply” button.

6:25

Tap 2

Back

Name: n=1.5

Info.: Input description for this material data.

| # | f [THz]  | $\mu'$   | $\mu''$  | $\epsilon'$ | $\epsilon''$ |
|---|----------|----------|----------|-------------|--------------|
| 0 | 1.20e+03 | 1.00e+00 | 0.00e+00 | 2.25e+00    | 0.00e+00     |
| 1 | 1.00e-01 | 1.00e+00 | 0.00e+00 | 2.25e+00    | 0.00e+00     |

Tap 3

f [THz] = 299.792458

$\mu' = 1.0$  ,  $\mu'' = 0.0$

$\epsilon' = 1.0$  ,  $\epsilon'' = 0.0$

Insert below the last layer

SavePlot

Simulation

Library

Save/Load

Setting/Etc

Tap 1



14. Perform the identical procedure for #1 row of the table. Then save it by tapping the “Save” button. Finally, a third user-defined material is created. Tap the “Back” button.

6:26

< Back

← Tap 3

Name: n=2.5

Info.: Input description for this material data.

| # | f [THz]  | $\mu'$   | $\mu''$  | $\epsilon'$ | $\epsilon''$ |
|---|----------|----------|----------|-------------|--------------|
| 0 | 1.20e+03 | 1.00e+00 | 0.00e+00 | 6.25e+00    | 0.00e+00     |
| 1 | 1.00e-01 | 1.00e+00 | 0.00e+00 | 6.25e+00    | 0.00e+00     |

↑ Tap 1

f [THz] = 299.792458

$\mu' = 1.0$  ,  $\mu'' = 0.0$

$\epsilon' = 1.0$  ,  $\epsilon'' = 0.0$

Insert below the last layer

Save

Plot

Simulation

Library

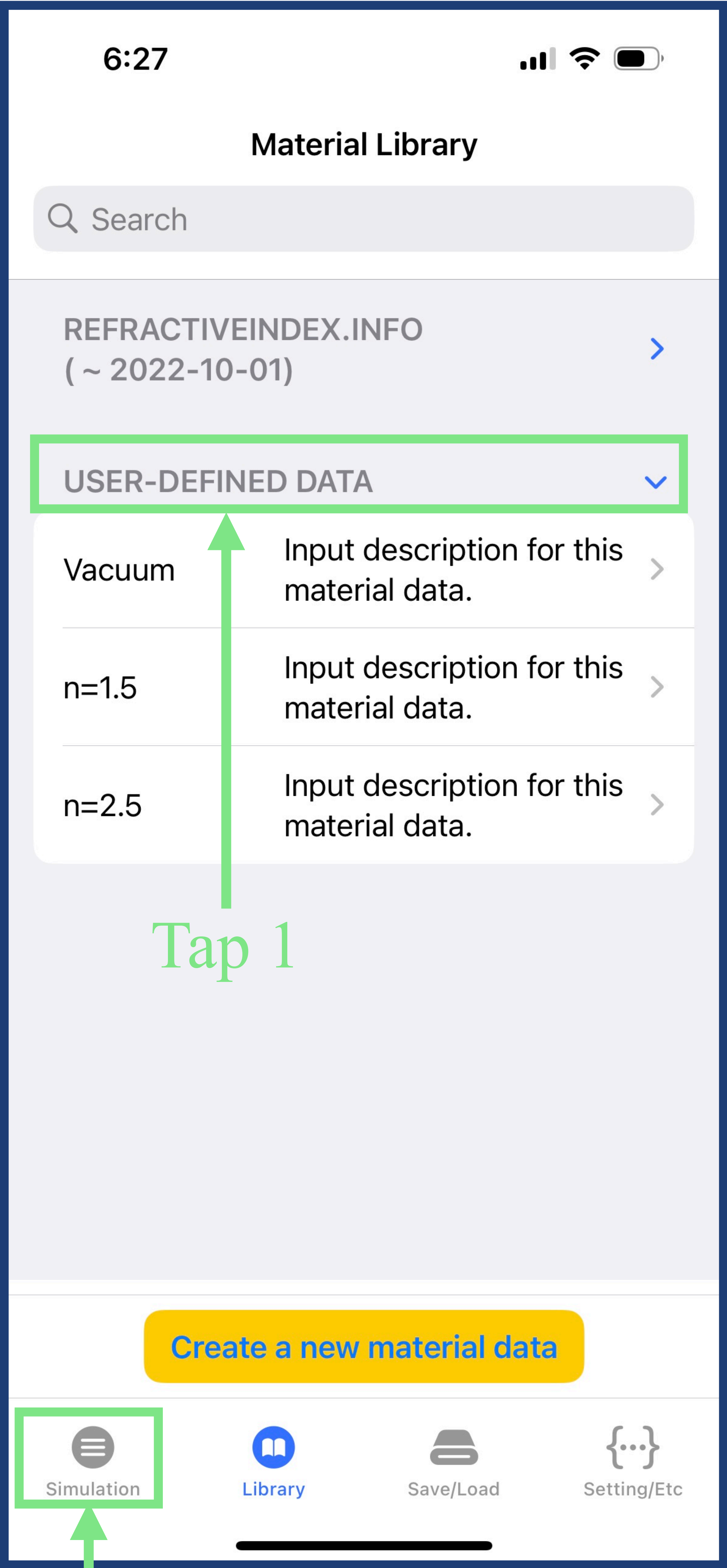
Save/Load

Setting/Etc

Tap 2

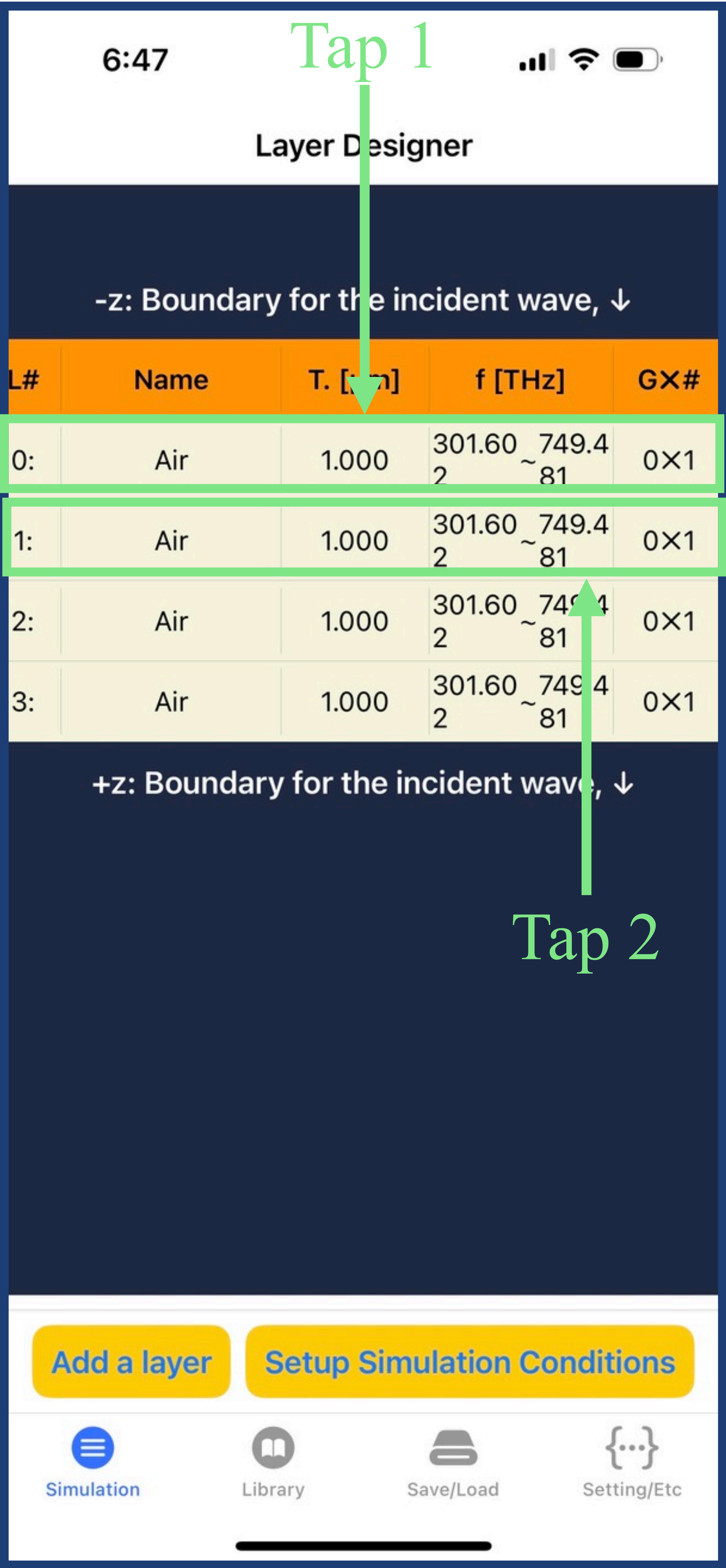


15.By tapping the USER-DEFINED DATA section, we can confirm the three newly created materials. Tap the “Simulation” icon.

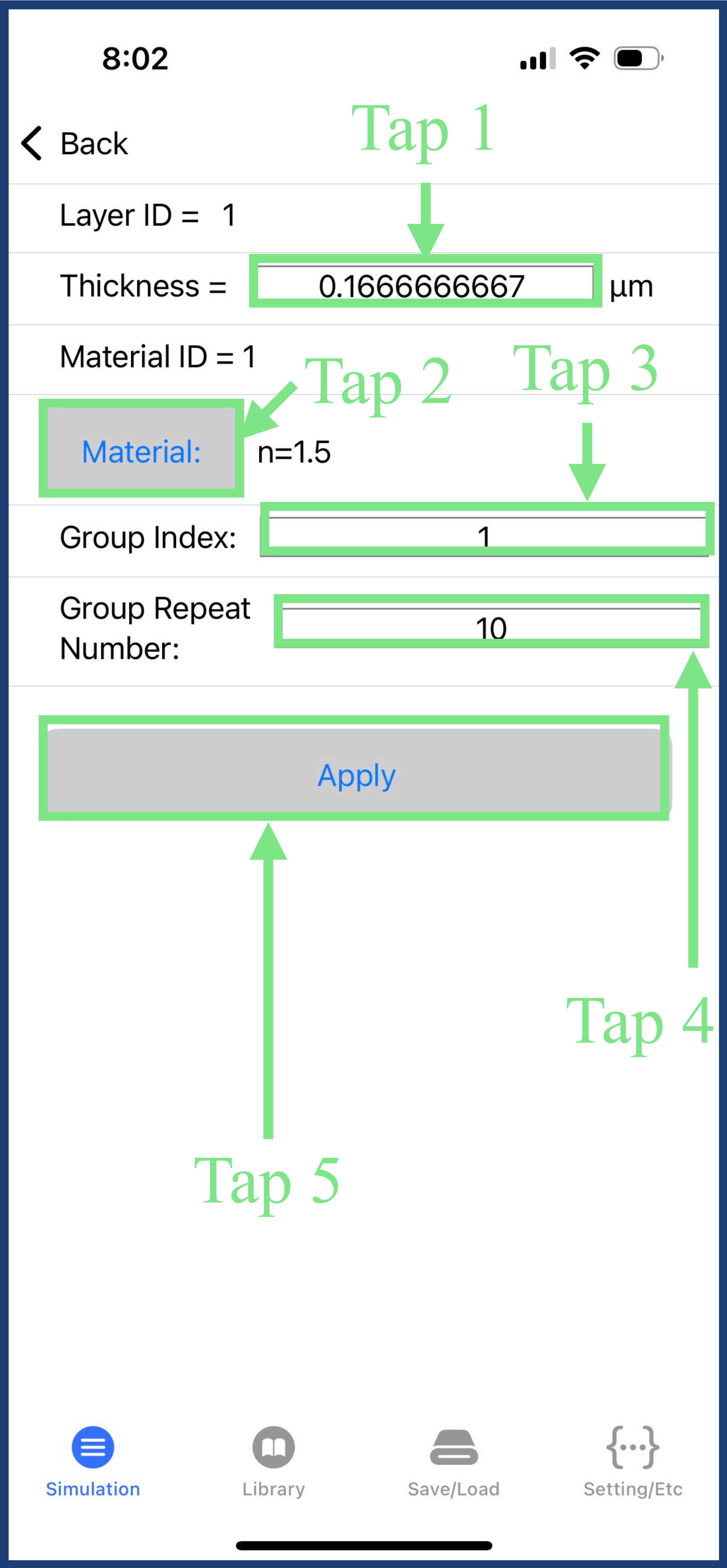




16. Change “Air” to the newly created “Vacuum” for L#0 layer after tapping it. Then tap layer L#1. L#0 becomes boundary material, and it must be lossless in E2M.



17. Tap the “Thickness” field and enter 0.1666666667. After you tap “Material”, select “n=1.5” to choose the material. Then, change “Group Index” to 1 and “Group Repeat Number” to 10. After that, tap “Apply” button.





18. Tap row L#3 and then select the material named “n=1.5”. It becomes the boundary material for +z direction. It can be thought as an infinite substrate in this tutorial.

8:03

Layer Designer

-z: Boundary for the incident wave, ↓

| L# | Name   | T. [μm] | f [THz]              | GX#  |
|----|--------|---------|----------------------|------|
| 0: | Vacuum | 1.000   | 0.100 ~ 1,200.000000 | 0×1  |
| 1: | n=1.5  | 0.167   | 0.100 ~ 1,200.000000 | 1×10 |
| 2: | Air    | 1.000   | 300.243 ~ 749.481    | 0×1  |
| 3: | Air    | 1.000   | 300.243 ~ 749.481    | 0×1  |

+z: Boundary for the incident wave, ↓

Tap

Add a layer

Setup Simulation Conditions

≡

Simulation

📖

Library

💾

Save/Load

{...}

Setting/Etc



19. Choose the material “2.5” after tapping the L#2 row. Also, change the thickness to 0.1, set the group index to 1, and set the group repeat number to 10.

8:15

Layer Designer

-z: Boundary for the incident wave, ↓

| L# | Name   | T. [μm] | f [THz]              | GX#  |
|----|--------|---------|----------------------|------|
| 0: | Vacuum | 1.000   | 0.100 ~ 1,200.000000 | 0×1  |
| 1: | n=1.5  | 0.167   | 0.100 ~ 1,200.000000 | 1×10 |
| 2: | Air    | 1.000   | 300.243 ~ 749.481    | 0×1  |
| 3: | n=1.5  | 1.000   | 0.100 ~ 1,200.000000 | 0×1  |

+z: Boundary for the incident wave, ↓

Tap

Add a layer

Setup Simulation Conditions

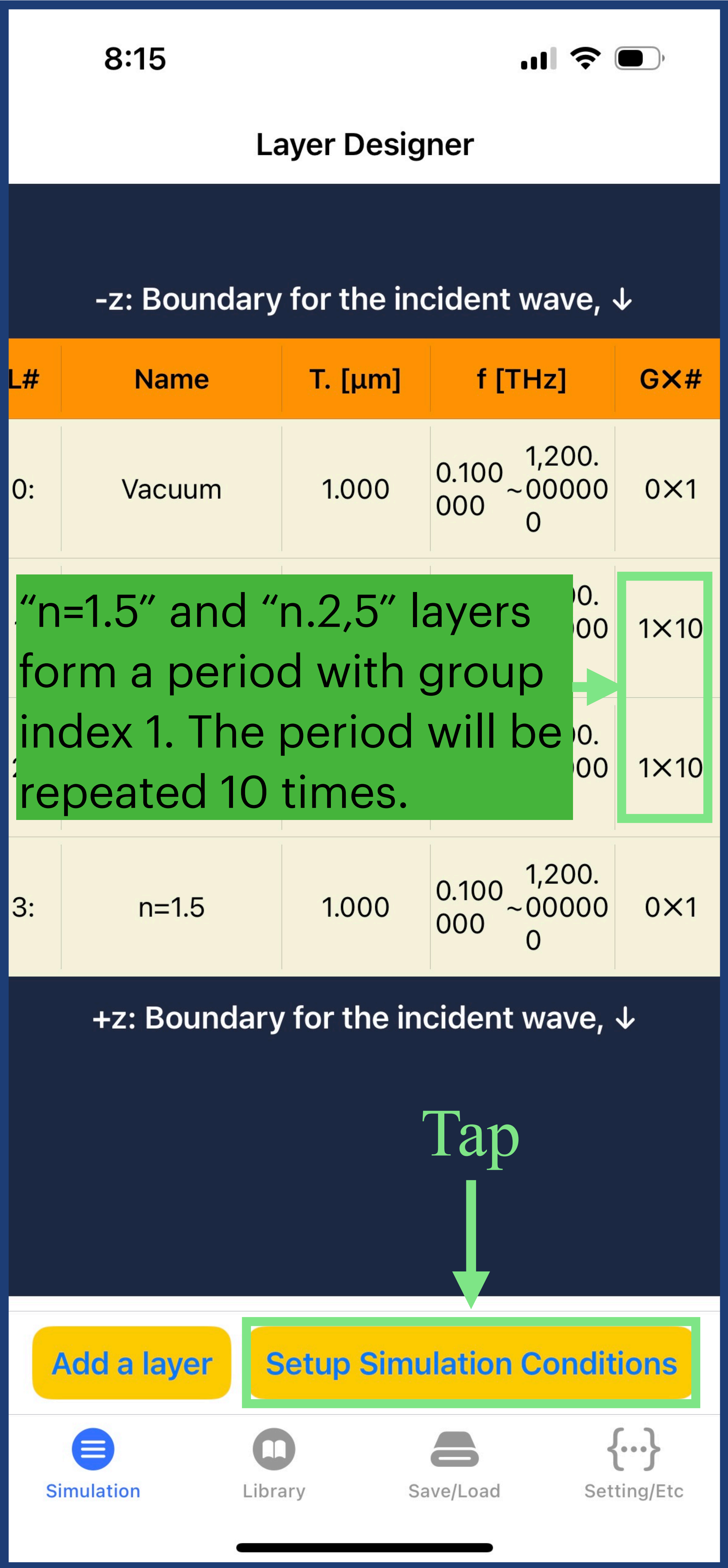
Simulation

Library

Save/Load

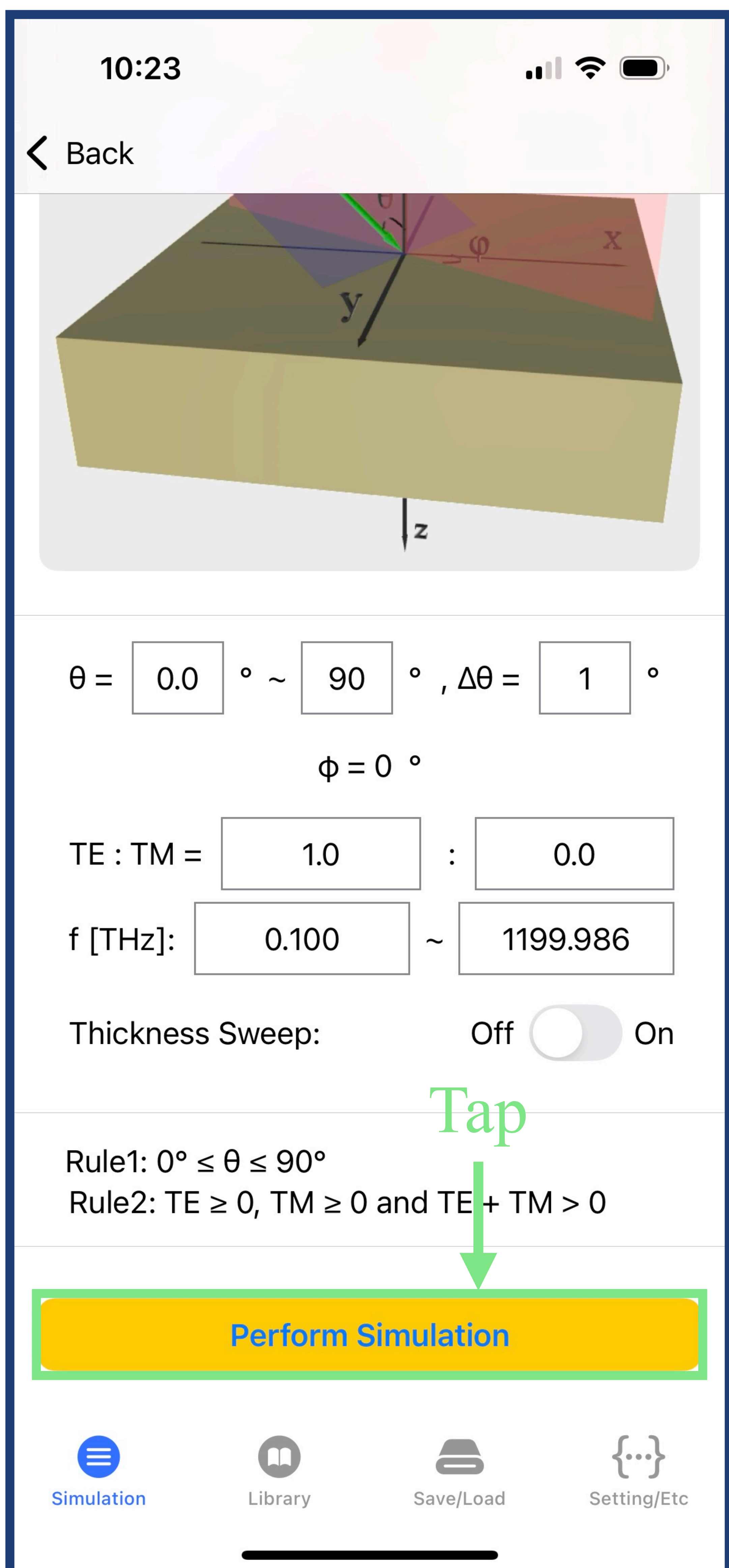
Setting/Etc

20. With the existence of identical group indices right below or up, a periodic structure is internally created. Such a period is repeated as the group repeat number. Tap the “Setup Simulation Conditions” button.



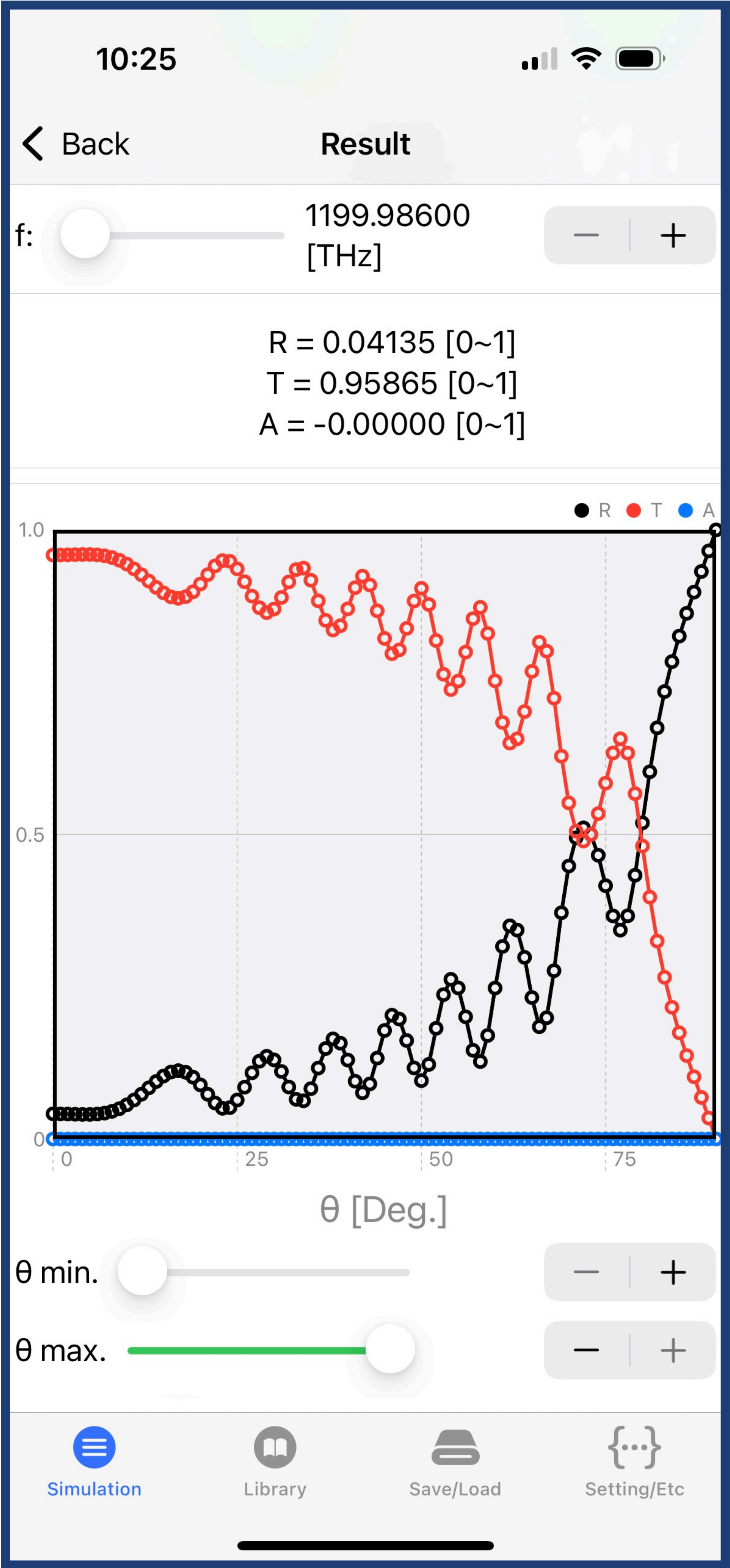


21. Simulating only for  $\theta = 0.0^\circ$  is enough to recalculate the target reference. However, we fill in  $\theta = 0.0^\circ \sim 90.0^\circ$  with  $\Delta\theta = 1^\circ$  to practice more features of E2M. After all filling finished, tap “Perform Simulation” button.



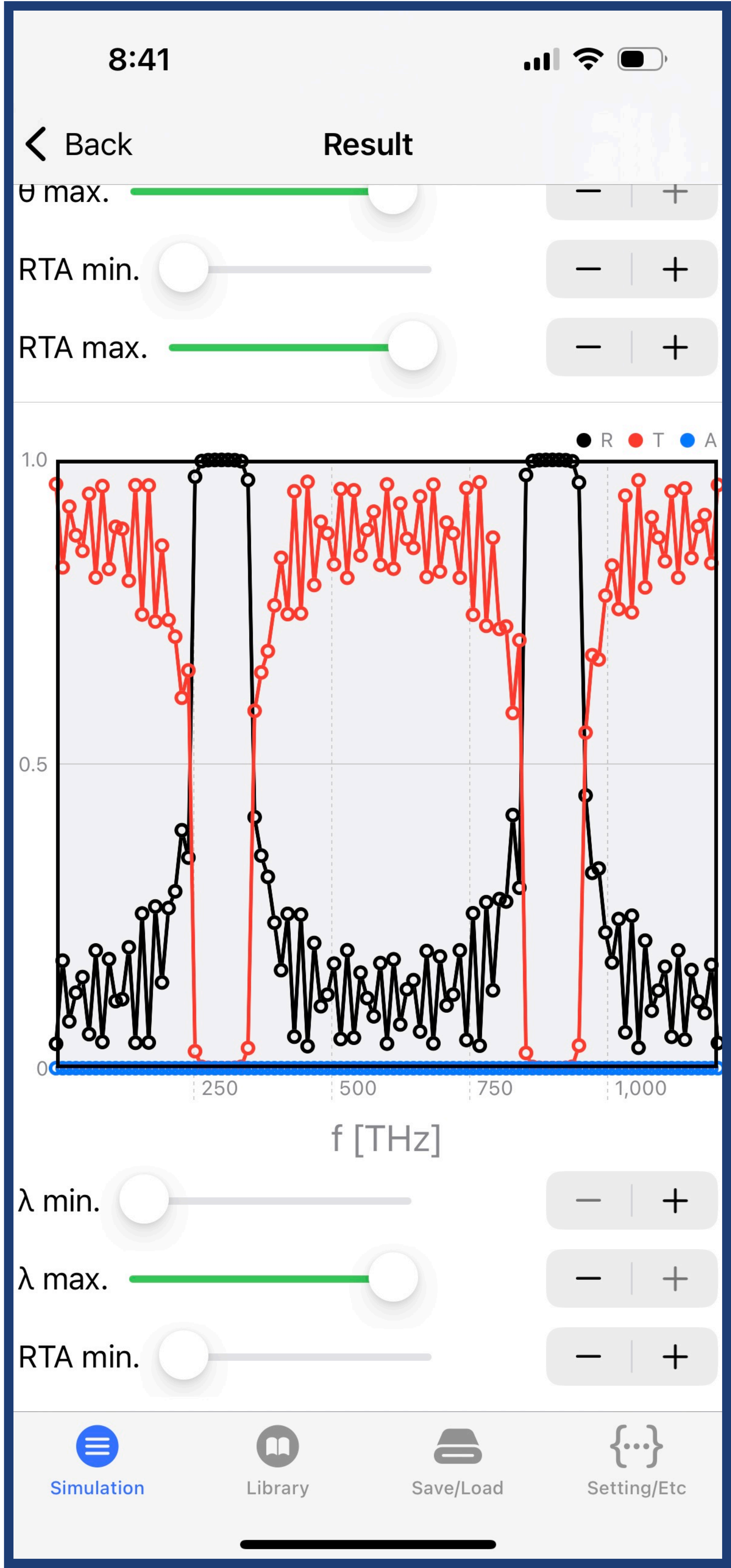


22. By slightly swiping up, we can see the RTA vs.  $\theta$  figure. If users control the slide bar or  $-/+$  buttons for  $f$ , then the RTA vs.  $\theta$  figure will be redrawn to present the result related to the frequency.



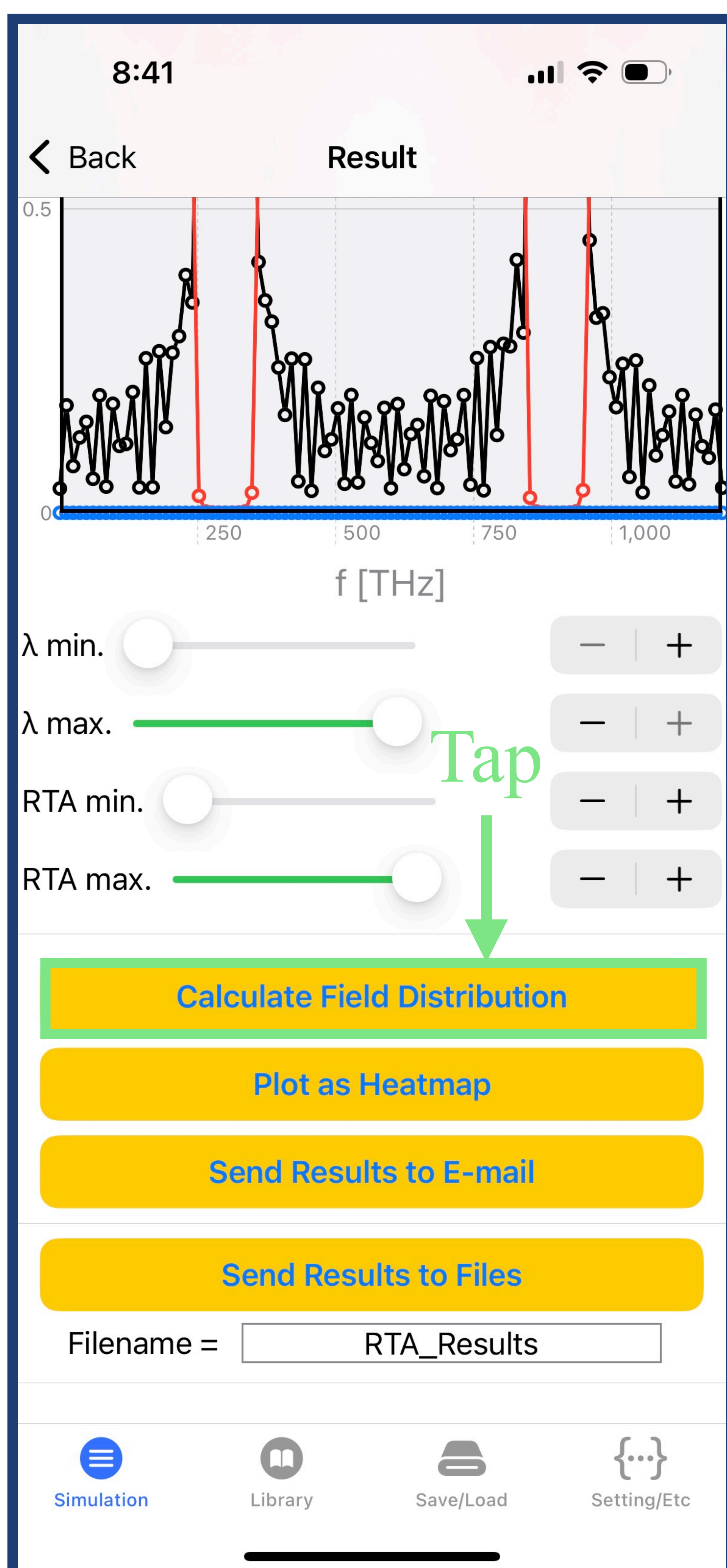


23. By swiping up more, we can see RTA vs.  $f$  figure. It shows very similar R result with the reference's lower-side figure. If you want to observe a better matching result, increase the “# of  $f$  for RTA” after tapping “Setting/Etc” icon.



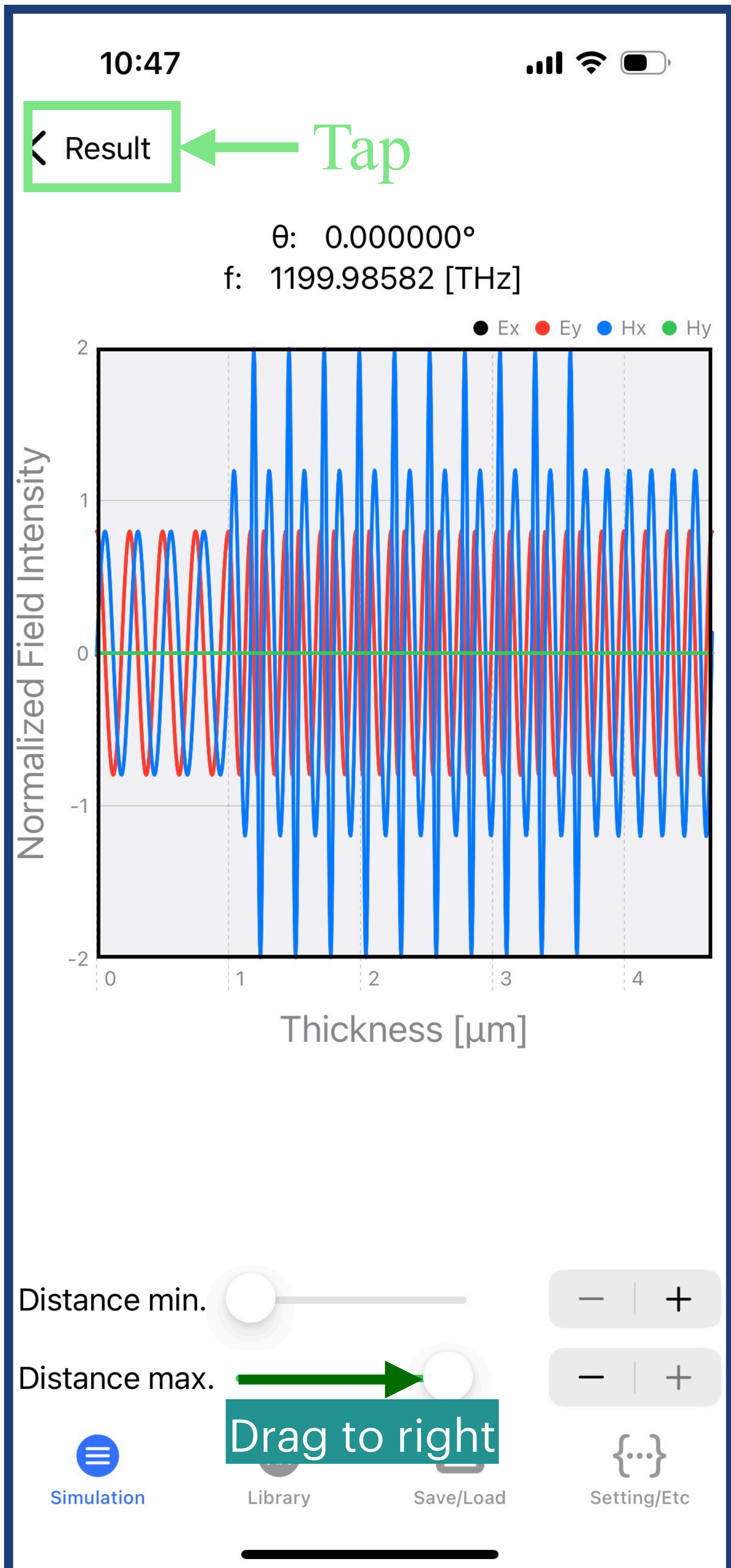


24. By swiping up more, we can see several buttons. Among those, tap “Calculate Field Distribution”. Then,  $E_x$ ,  $E_y$ ,  $H_x$ , and  $H_y$  field distributions are calculated as functions of depth. Before tapping, users may try to control the not-introduced sliders and  $-/+$  buttons freely.



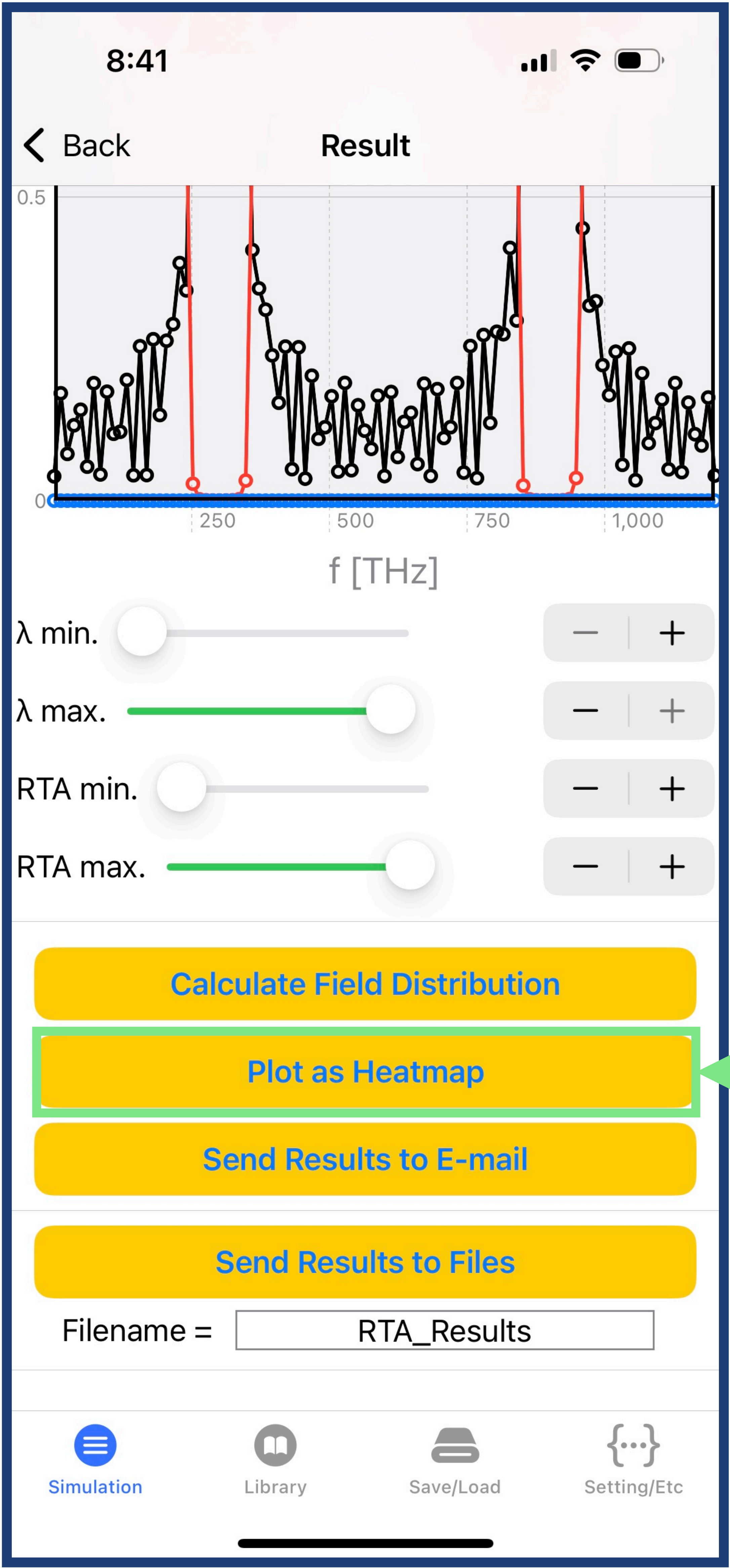


25. Drag the “Distance max.” slider to the most right. Then, you may observe the field distribution. Each field is normalized state. After observation, tap the “< Result” button.



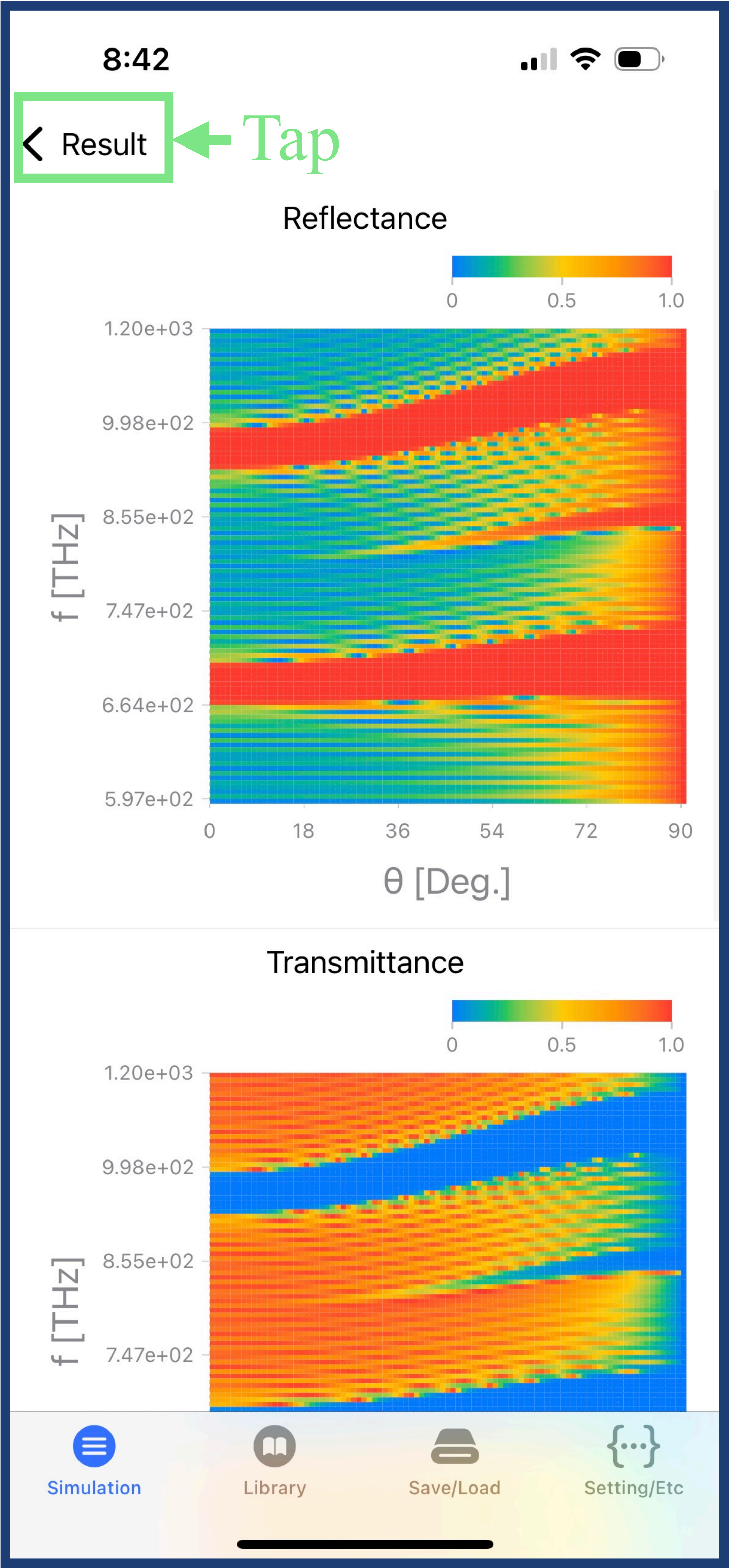


26. As a next, tap the “Plot as Heatmap” button.



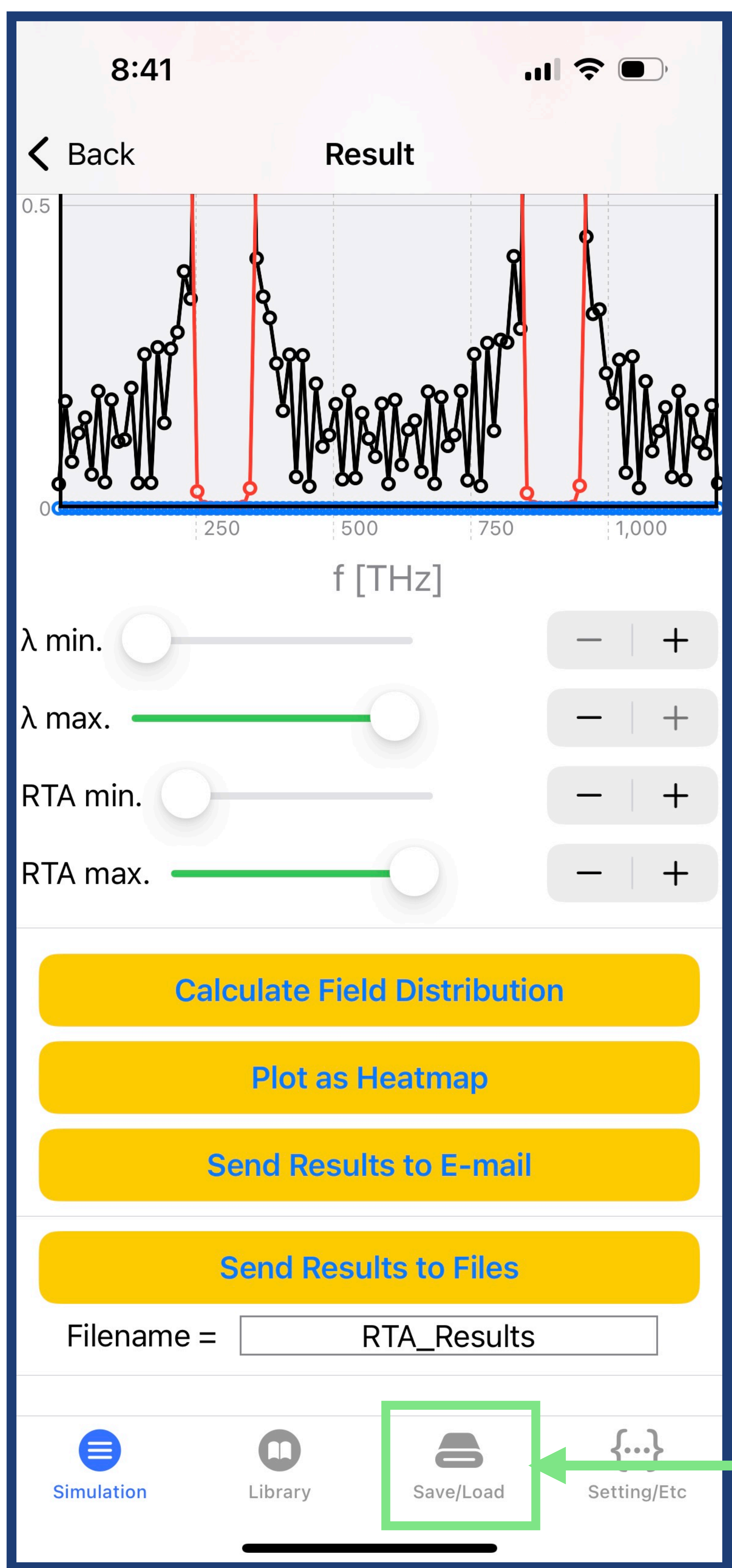


27. Observe heatmap plots of reflectance, transmittance and absorptance by swiping up and down. Then tap the “< Result” button to go back.

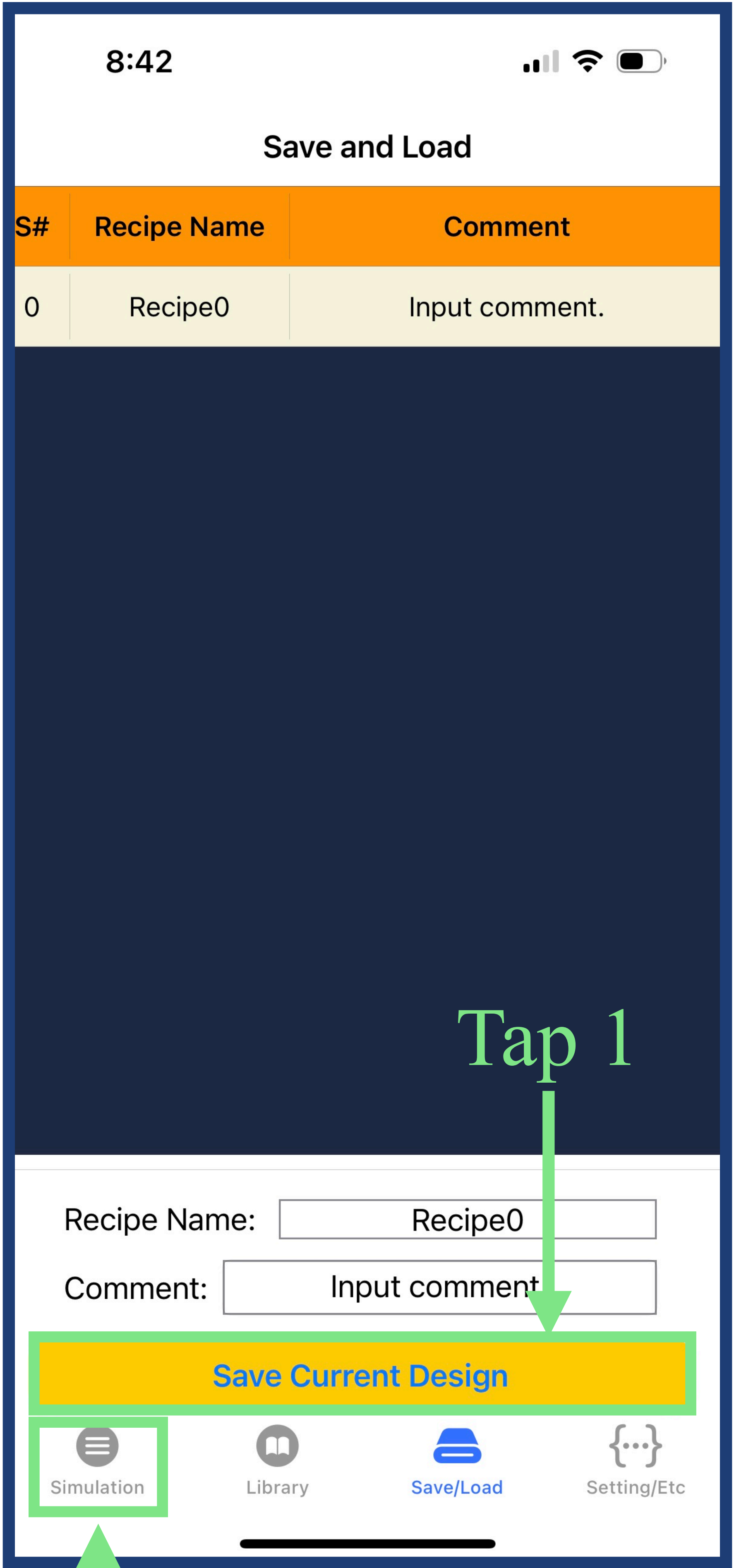




28. Raw data and figures can be exported. To export, tap “Send Results to E-mail” or “Send Results to Files”. Also, designed layers and simulation conditions can be saved in E2M. Tap the “Save/Load” icon.



29. Input “Recipe Name” and “Comment” fields. Afterward, tap the button labeled “Save Current Design”. If you want to load your previously saved design, tap a row of S# what you want to load, then tap the “Load This Recipe” button. We have one more figure of reference to recalculate. Tap the “Simulation” icon after saving.





30. Go to the “Layer Designer” page. Next, tap row L#0, and change the material from “Vacuum” to “n=1.5” as shown below. After that, perform a simulation under the identical conditions performed before.

9:48

Layer Designer

Tap 1

-z: Boundary for the incident wave, ↓

| L# | Name  | T. [μm] | f [THz]                 | GX#  |
|----|-------|---------|-------------------------|------|
| 0: | n=1.5 | 1.000   | 0.100 1,200.000 ~000000 | 0×1  |
| 1: | n=1.5 | 0.167   | 0.100 1,200.000 ~000000 | 1×10 |
| 2: | n=2.5 | 0.100   | 0.100 1,200.000 ~000000 | 1×10 |
| 3: | n=1.5 | 1.000   | 0.100 1,200.000 ~000000 | 0×1  |

+z: Boundary for the incident wave, ↓

Tap 2

Add a layer

Setup Simulation Conditions

Simulation

Library

Save/Load

Setting/Etc



31. After performing the simulation, we can observe the RTA vs.  $f$  spectrum as below. Extracted results show identical results to the upper-side figure of the reference.

