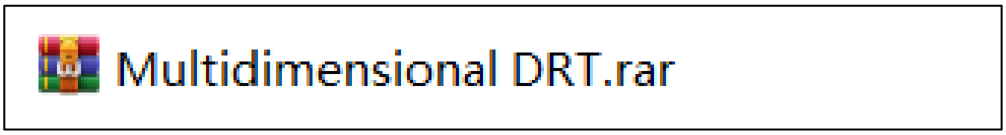
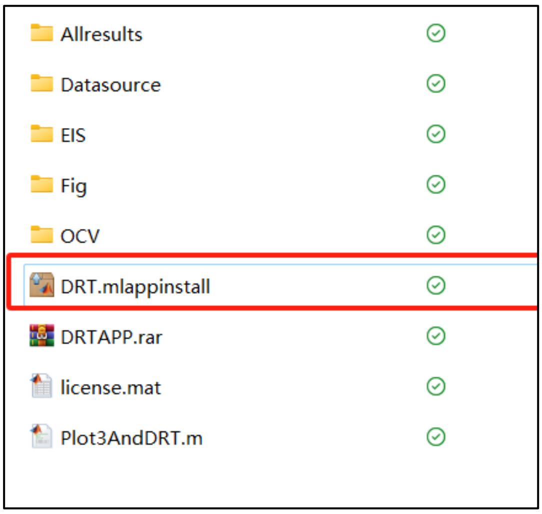
DRT User Manual

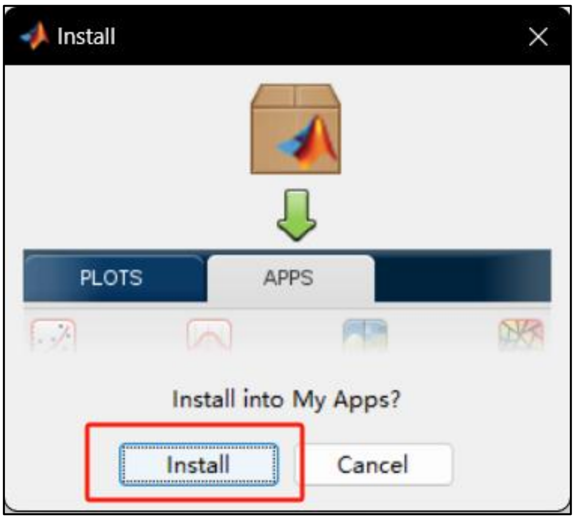
1. Software Installation and Activation

1.1 Extract the **.rar** file to the current folder.

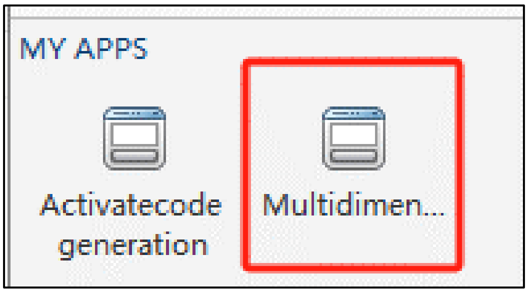


1.2 Open the MATLAB software and double-click **DRT.mlappinstall** to install.



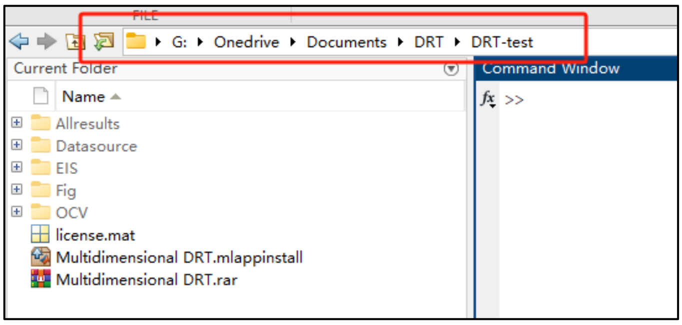


1.3 Click the downward triangle drop-down button, and you will find the installed **Multidimensional DRT app** in **My Apps** .



1.4 Activation

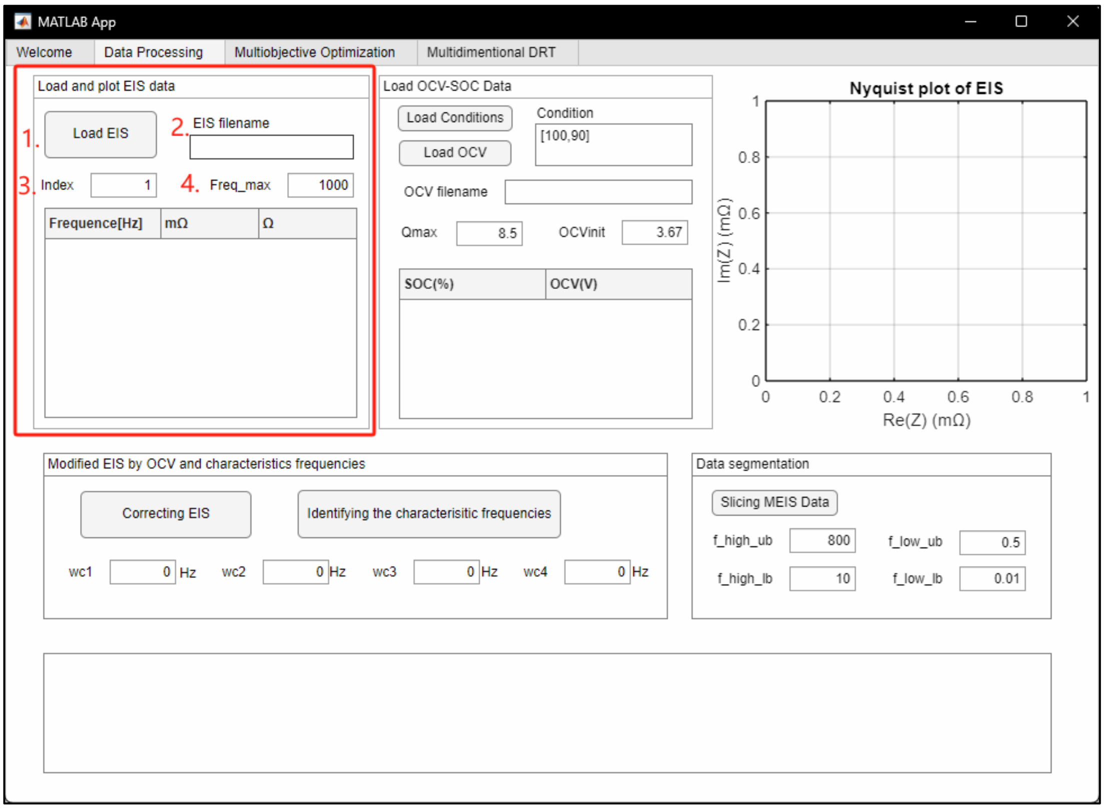
First, ensure that the path in MATLAB is set to the current installation path, and keep this path unchanged for subsequent runs! (important). The current installation path is the extraction path, which is the same path where folders like Allresults are located.



When running the app for the first time, activation procedure is required. Send the **Computer ID** to Xue.Cai@isea.rwth-aachen.de **or** Weihan.Li@isea.rwth-aachen.de , and enter the returned activation code in the **Activation code column**. Click **Activate** to start. After activation is complete, it will jump to the user interface. No reactivation is required for subsequent startups.

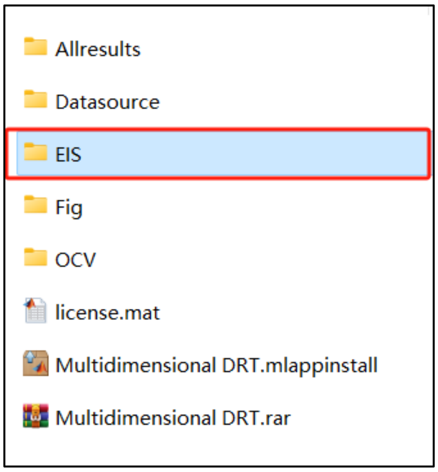
2. Data Processing

Ensure that the path in MATLAB is set to the current installation path, and keep this path unchanged for subsequent runs! (important). **(See the tip from the previous step)**



2.1 Load and Plot EIS data

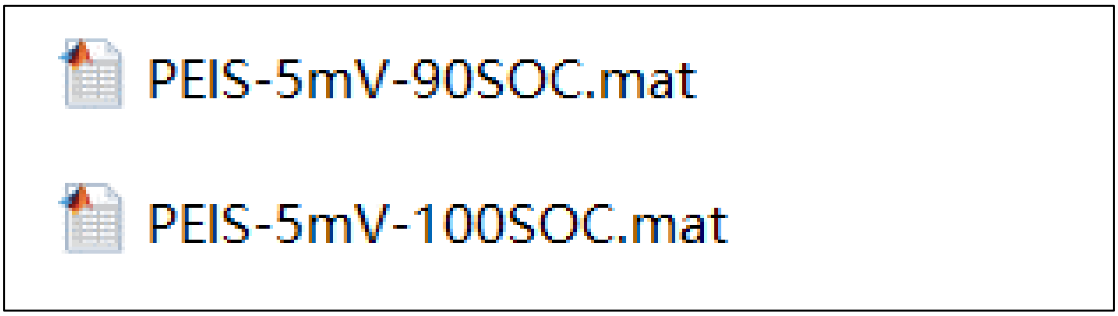
Click the **Load EIS** button to read the EIS data **from the folder EIS**.



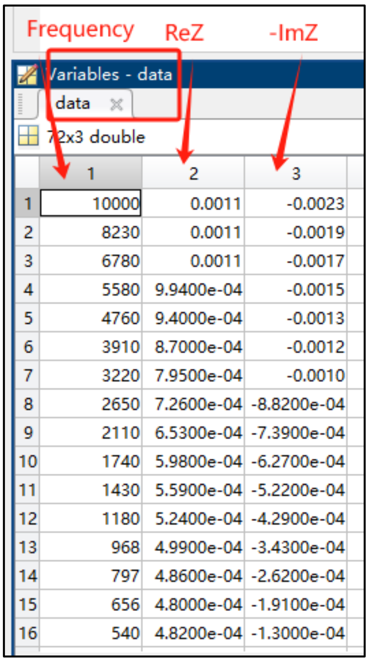
Please ensure the EIS files follow the correct naming conventions:

Example :

PEIS-5mV-100SOC.mat (Potentiostatic mode - amplitude 5mV - 100% SOC)
GEIS-8A-100SOC.mat (Galvanostatic mode - amplitude 8A - 100% SOC)
SOC and amplitude are inputs for MGEIS, directly determining which code to use (mgeis or mpeis).

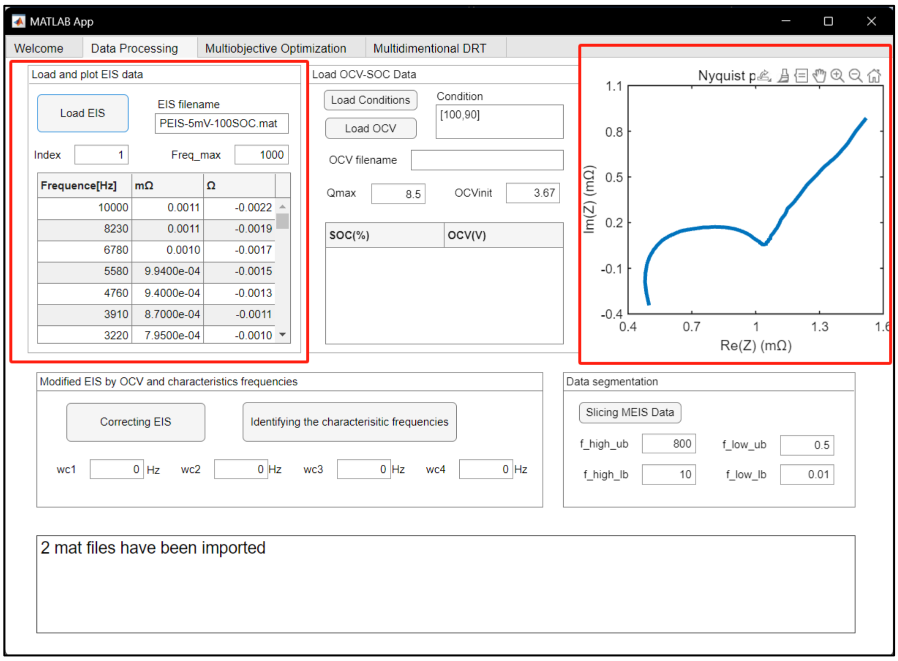


The data structure of EIS is as follows :
EIS data consists of three columns: the first column is **Frequency**, the second column is **ReZ**, and the third column is **-ImZ.** These data are stored under the variable **data** in the workspace and finally saved in the **.mat** file.

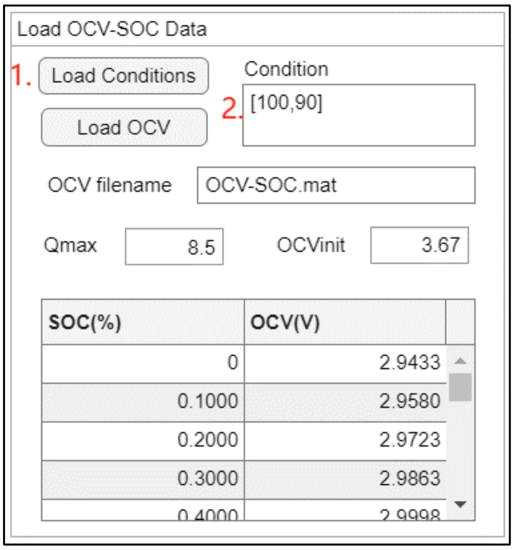


	1	2	3
1	10000	0.0011	-0.0023
2	8230	0.0011	-0.0019
3	6780	0.0011	-0.0017
4	5580	9.9400e-04	-0.0015
5	4760	9.4000e-04	-0.0013
6	3910	8.7000e-04	-0.0012
7	3220	7.9500e-04	-0.0010
8	2650	7.2600e-04	-8.8200e-04
9	2110	6.5300e-04	-7.3900e-04
10	1740	5.9800e-04	-6.2700e-04
11	1430	5.5900e-04	-5.2200e-04
12	1180	5.2400e-04	-4.2900e-04
13	968	4.9900e-04	-3.4300e-04
14	797	4.8600e-04	-2.6200e-04
15	656	4.8000e-04	-1.9100e-04
16	540	4.8200e-04	-1.3000e-04

The user needs to manually set **Index** to load the n-th file in the EIS folder. and **Freq_max** (Maximum Frequency). Freq_max represents the frequency point from which **fitting begins**.
After clicking the **Load EIS** button, the data will be read, and the current file name will be displayed in the **EIS filename** (2.). The data will be shown in the table indicated by (5.). When there are multiple EIS files in the **EIS** folder, you can specify the EIS file to read by changing the **index** (3.).
The loaded EIS data will be plotted in the drawing area on the right.



2.2 Load Conditions



First, you need to set the EIS conditions. There are two ways to set the conditions:

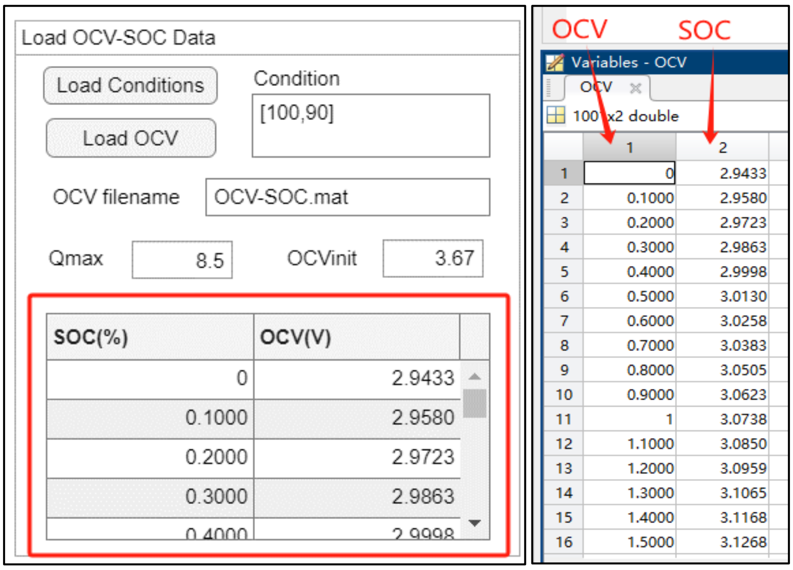
1. Click the **Load Conditions** button to read the **conditions.mat** file from the current folder (the extraction folder). Modifying this file can change the conditions.
2. Directly modify the conditions in the **Condition** box on the right.

Please ensure the number of conditions matches the number of files read in the previous step.

2.3 Load OCV-SOC data for correcting

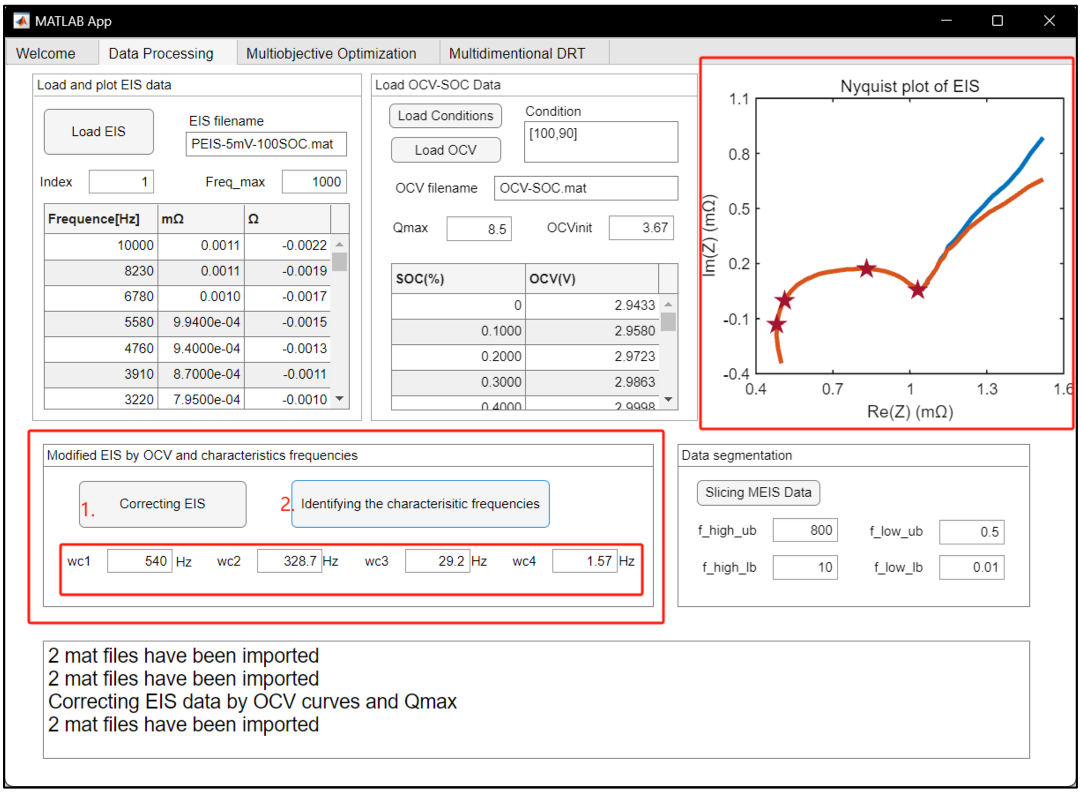
The user needs to set **Qmax** and **OCVinit** manually.
Click the **Load OCV** button to read the OCV-SOC data needed for correcting the EIS from the **OCV** folder, the OCV-SOC data structure show in blow. If you do not need to correct the EIS, simply **Load Conditions** in this step and skip **Load OCV** and **Correcting EIS** steps.
Similarly, the loaded OCV-SOC data will be displayed in the table below.

OCV-SOC data structure:



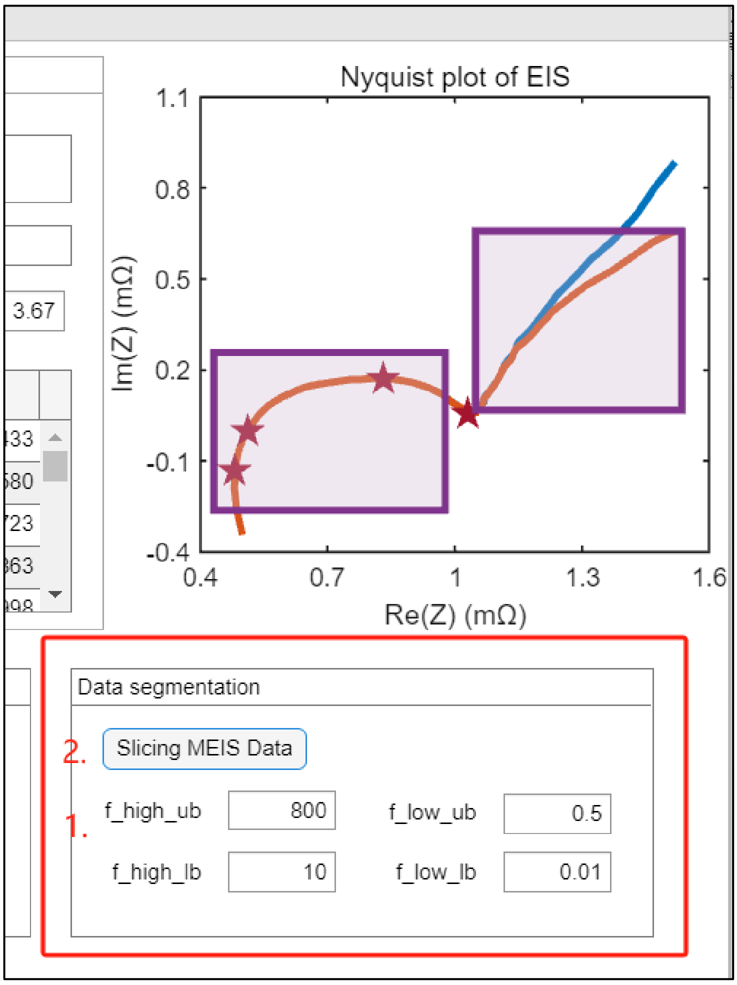
2.3 Modified EIS by OCV and characteristics frequencies

Click **Correcting EIS** to correct the EIS curve based on the OCV-SOC data read in the previous step. Click **Identifying the characteristic frequencies** to identify the characteristic frequencies. The four identified characteristic frequencies will be displayed below. The corrected EIS curve and the four identified points will also be plotted in the drawing area on the right.


MATLAB App
Welcome
Data Processing
Multiobjective Optimization
Multidimentional DRT
Load and plot EIS data
Load EIS
EIS filename
PEIS-5mV-100SOC.mat
Index 1
Freq_max 1000
Frequence[Hz] mΩ Ω
10000 0.0011 -0.0022
8230 0.0011 -0.0019
6780 0.0010 -0.0017
5580 9.9400e-04 -0.0015
4760 9.4000e-04 -0.0013
3910 8.7000e-04 -0.0011
3220 7.9500e-04 -0.0010
Load OCV-SOC Data
Load Conditions
Condition
[100,90]
Load OCV
OCV filename
OCV-SOC.mat
Qmax 8.5
OCVinit 3.67
SOC(%) OCV(V)
0 2.9433
0.1000 2.9580
0.2000 2.9723
0.3000 2.9863
Nyquist plot of EIS
Im(Z) (mΩ)
Re(Z) (mΩ)
Modified EIS by OCV and characteristics frequencies
1. Correcting EIS
2. Identifying the characterisitic frequencies
wc1 540 Hz
wc2 328.7 Hz
wc3 29.2 Hz
wc4 1.57 Hz
Data segmentation
Slicing MEIS Data
f_high_ub 800
f_low_ub 0.5
f_high_lb 10
f_low_lb 0.01
2 mat files have been imported
2 mat files have been imported
Correcting EIS data by OCV curves and Qmax
2 mat files have been imported

2.4 Data Segmentation

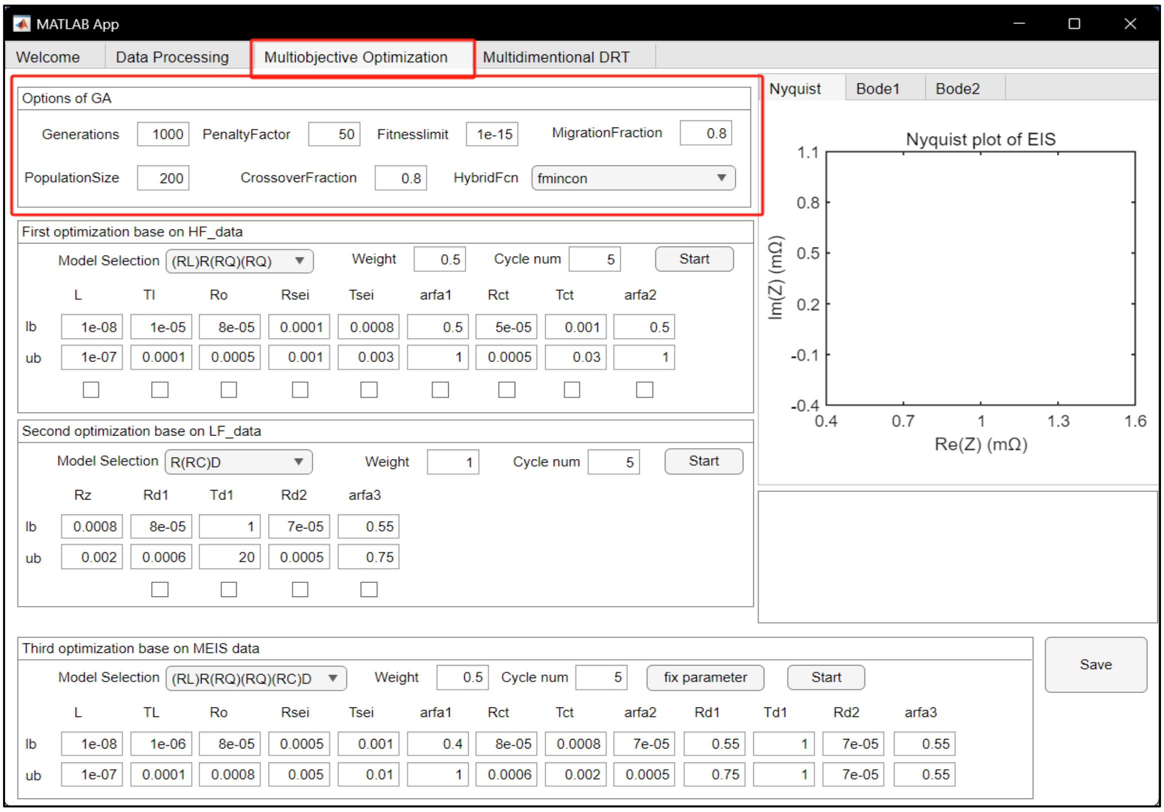
After the user sets the four boundaries, click **Slicing MEIS Data.** The corrected EIS curve will be divided into high-frequency and low-frequency segments, which will be displayed in the upper right drawing area.



3. Multiobjective Optimization

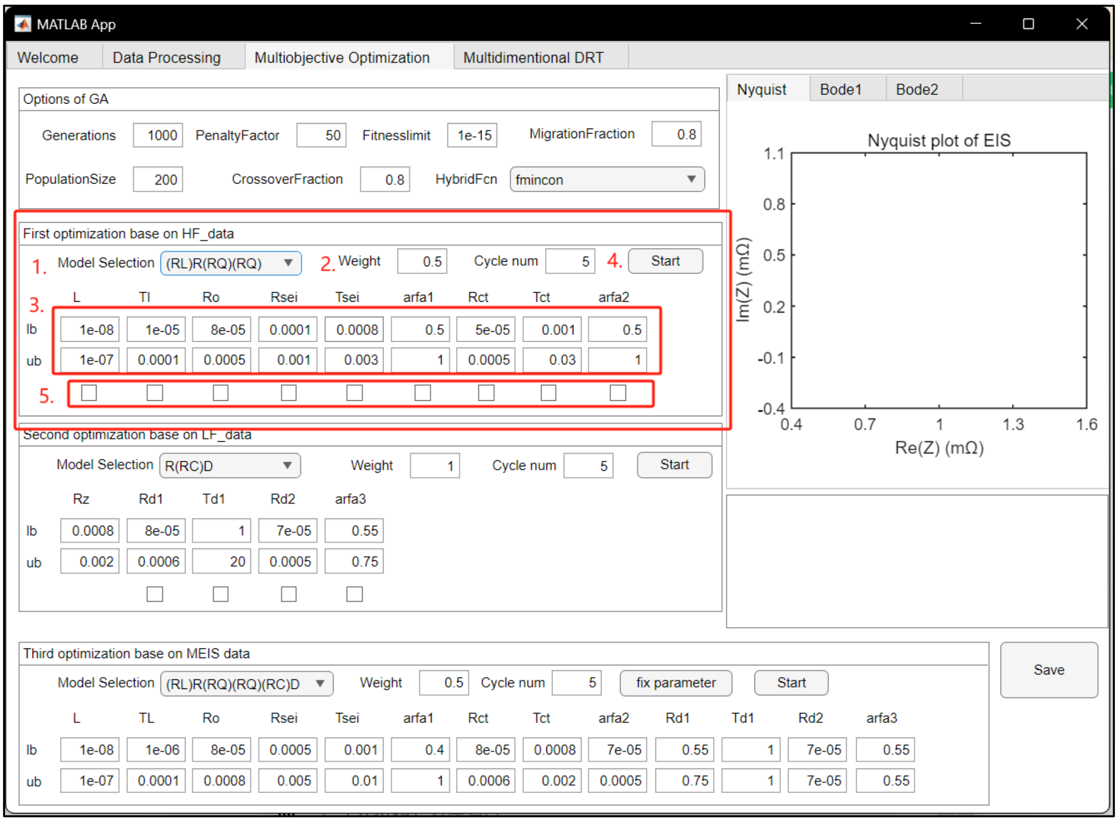
3.1 Set the Genetic Algorithm (GA) parameters.

Generations: Number of generations, i.e., the maximum number of generations the genetic algorithm will run. Setting it to 1000 means the algorithm will run for 1000 generations unless the stopping criteria are met earlier.
PenaltyFactor: Penalty factor. This parameter is typically used for handling constraint optimization problems by applying a penalty to the objective function when constraints are violated.
FitnessLimit: Fitness limit. The genetic algorithm will stop if a fitness value less than or equal to this value is found. Here, it is set to
MigrationFraction: Migration fraction. Used in multi-population optimization, it represents the proportion of individuals migrating from one population to another in each generation. Setting it to 0.8 means 80% of individuals can migrate.
PopulationSize: Population size. Indicates the number of individuals in each generation. Setting it to 200 means each generation has 200 individuals.
CrossoverFraction: Crossover ratio. Indicates the proportion of individuals participating in the crossover operation in each generation. Setting it to 0.8 means 80% of the individuals will undergo crossover.
HybridFcn: Hybrid function. Specifies the hybrid function used for further optimization after the genetic algorithm ends. Here, fmincon is chosen, which is a MATLAB function for solving constrained nonlinear optimization problems.

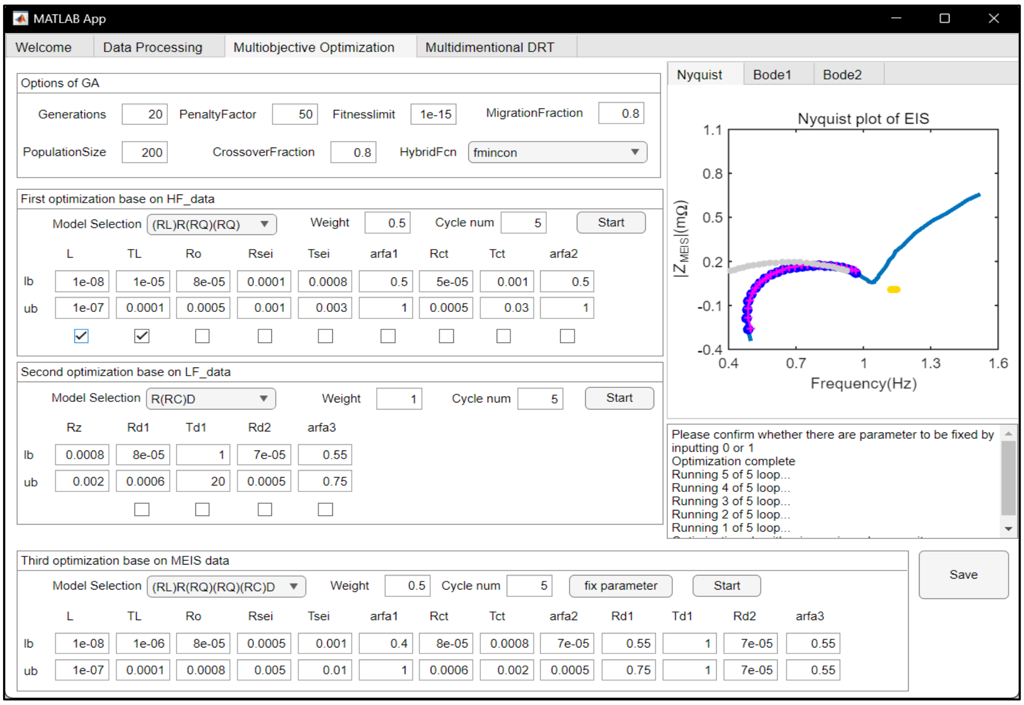


3.2 First optimization base on HF_data

First, set the high-frequency optimization model (1.), set the weights and the number of cycles (2.), and then set the upper and lower bounds for the optimization parameters (3.). Click the **Start** button(4.) to begin the high-frequency optimization.
In section (5.), check the boxes of parameters that need to be fixed.



The results of the run are shown in the figure blow.



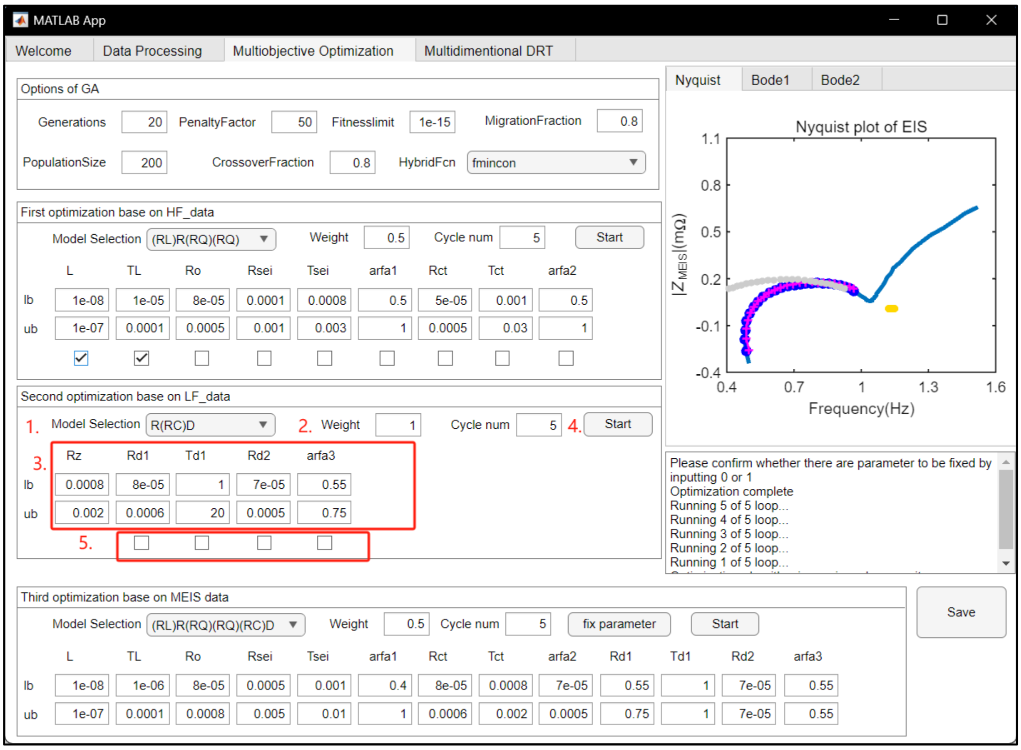
3.3 Second optimization base on LF_data

The operation is similar for low-frequency optimization.

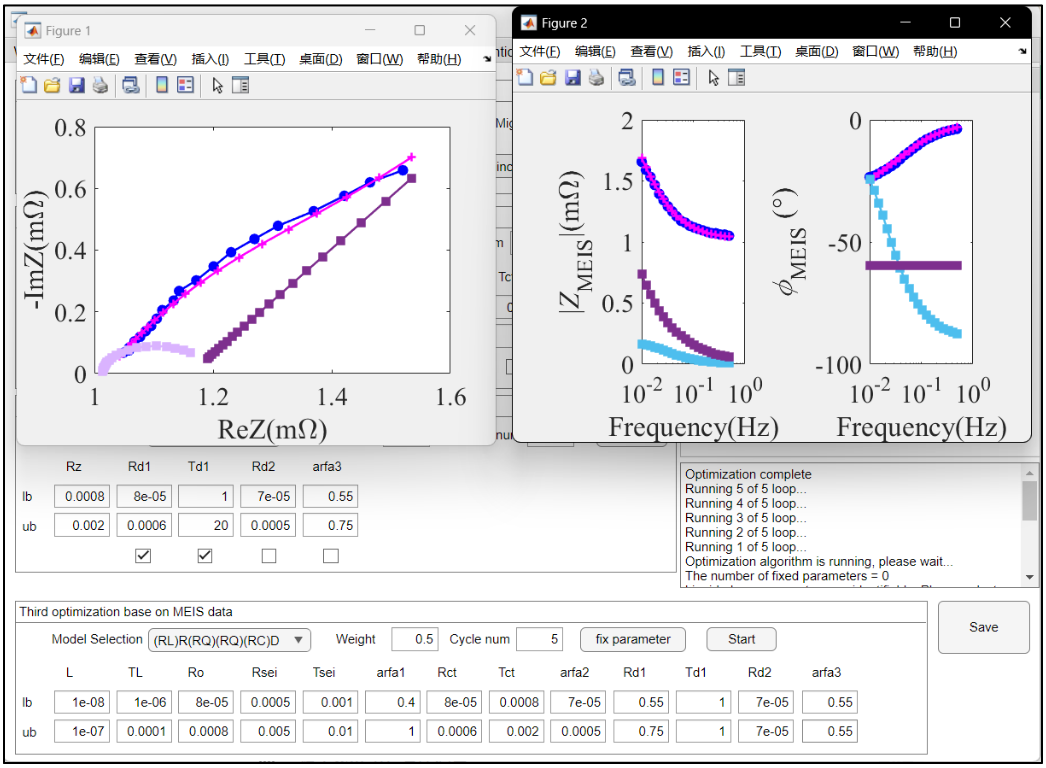
First, set the high-frequency optimization model (1.), set the weights and the number of cycles (2.), and then set the upper and lower bounds for the optimization parameters (3.).

Click the **Start** button(4.) to begin the high-frequency optimization.

In section (5.), check the boxes of parameters that need to be fixed.



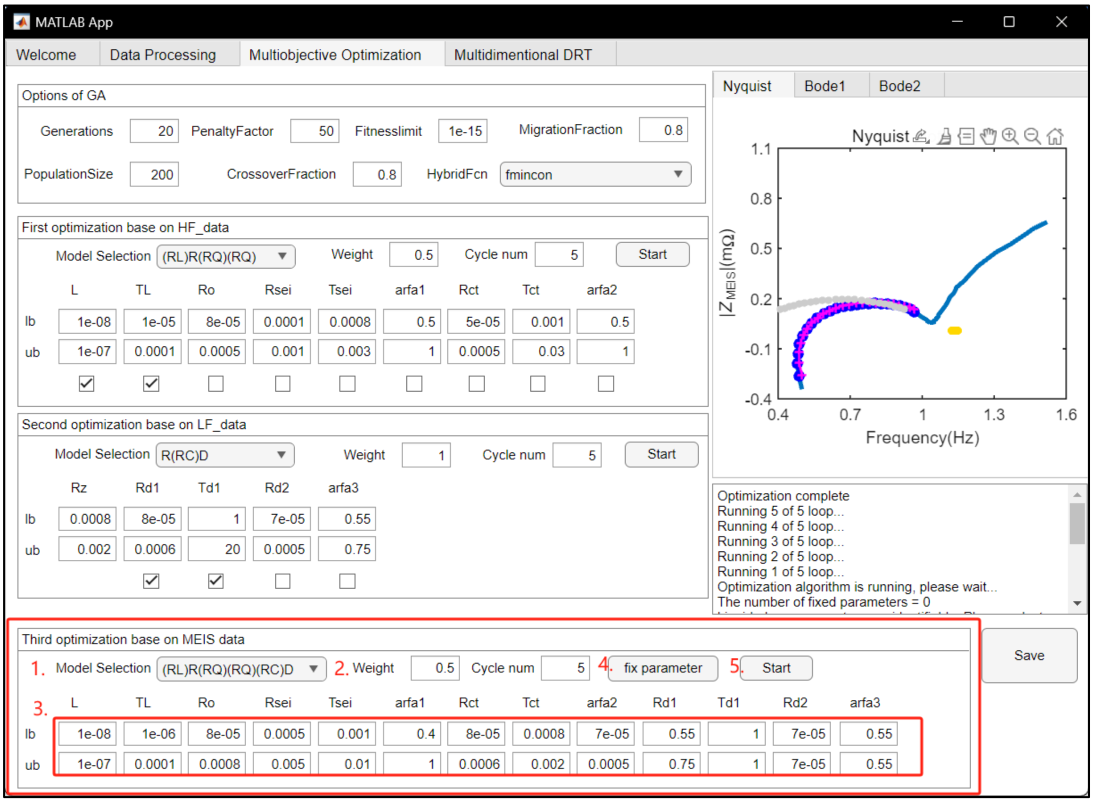
The results of the run are shown in the figure blow.



3.4 Third optimization base on MEIS data

First, set the high-frequency optimization model (1.), **The optimization model must remain consistent with the previous two optimization models.** set the weights and the number of cycles (2.), and then set the upper and lower bounds for the optimization parameters (3.).

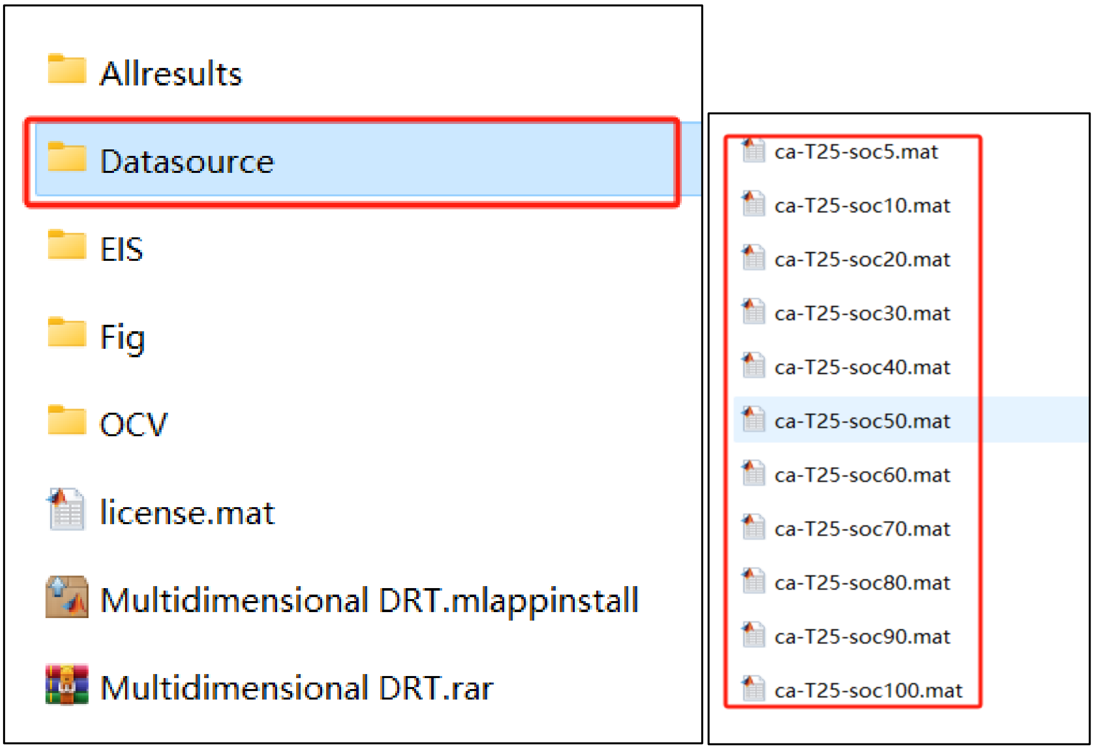
Click **Fix Parameter.** The parameters fixed in the previous two steps will be displayed in (3.) with consistent upper and lower bounds. Click **Start** (5.) to begin the third optimization.



If you want to save the data, click the **Save** button. The data from the three optimizations will be saved in the **Allresults** folder as the **Allresults.mat** file. The DRT data will be saved in the **Allresults** folder as the **drt.mat** file.

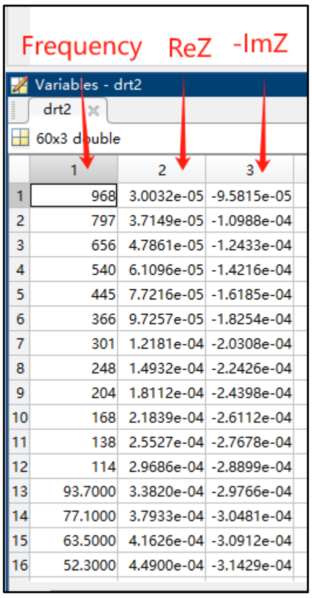
4. Multidementional DRT

This page will read the DRT analysis data from the **Datasource** folder.



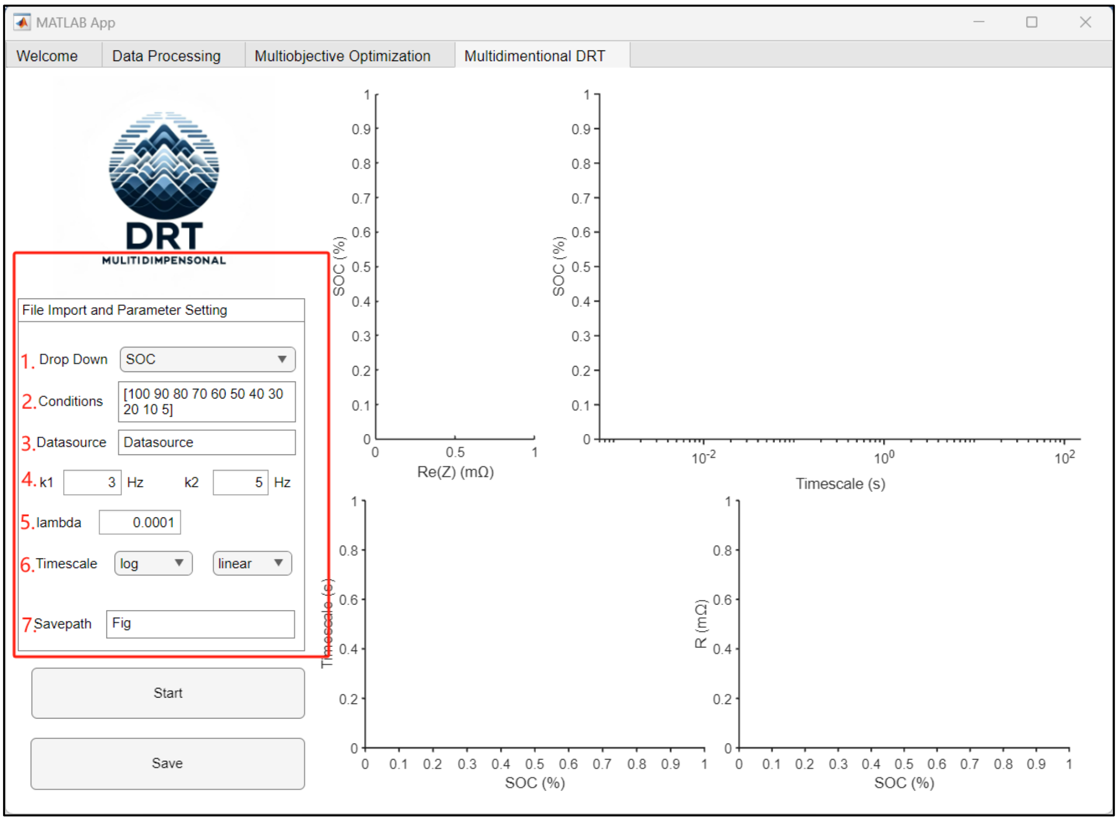
The data structure of the files in the **Datasource** folder is as follows:

Three columns of data, **Frequency, ReZ,** and **-ImZ,** are stored in the variable drt2. drt1 and drt3 are not involved in the analysis (it is possible for drt1 and drt3 to not exist).

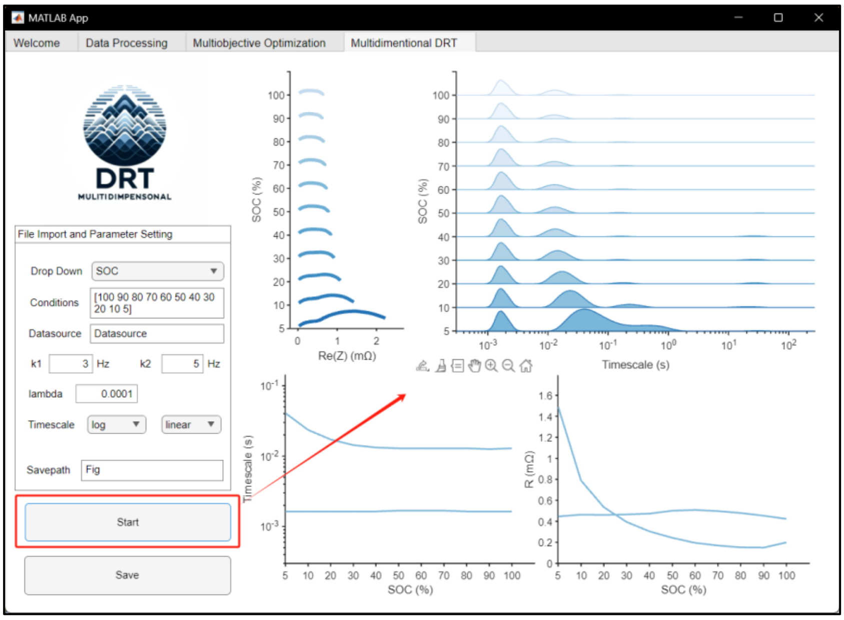


	1	2	3
1	968	3.0032e-05	-9.5815e-05
2	797	3.7149e-05	-1.0988e-04
3	656	4.7861e-05	-1.2433e-04
4	540	6.1096e-05	-1.4216e-04
5	445	7.7216e-05	-1.6185e-04
6	366	9.7257e-05	-1.8254e-04
7	301	1.2181e-04	-2.0308e-04
8	248	1.4932e-04	-2.2426e-04
9	204	1.8112e-04	-2.4398e-04
10	168	2.1839e-04	-2.6112e-04
11	138	2.5527e-04	-2.7678e-04
12	114	2.9686e-04	-2.8899e-04
13	93.7000	3.3820e-04	-2.9766e-04
14	77.1000	3.7933e-04	-3.0481e-04
15	63.5000	4.1626e-04	-3.0912e-04
16	52.3000	4.4900e-04	-3.1429e-04

In section (2.), set the Conditions to match the order of the files in the **Datasource** folder. In section (3.), set the data source folder for this page, which is **Datasource** by default and does not need to be changed. The user needs to manually set k1, k2 (section 4.), and lambda (section 5.). Section (7.) is the export path for images (after clicking Save), which defaults to the **Fig** folder and does not need to be changed.



Click the **Start** button, and the results will be plotted in the image on the right. Meanwhile, some **intermediate data** is saved in the **Allresults** folder.



Click the **Save** button, and the four images will be saved in the **Fig** folder.