RecurDyn/TSG Tutorial

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RecurDyn/TSG Tutorial (1)

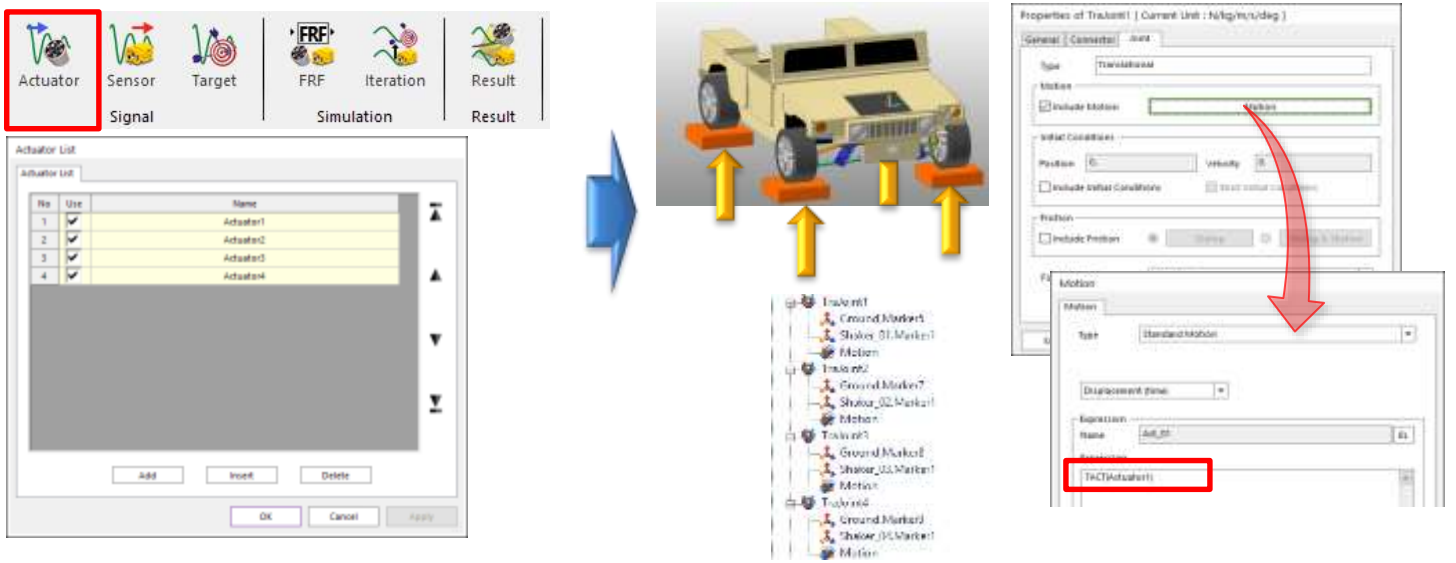
Actuator

Actuator : decides the number of the actuators

- As shown in the below figure. Select **Actuator** icon to open Actuator List dialog. Create 4 actuators using **Add** button.

Apply the actuators to the joints

- The actuators are used in Join Motion or Force using a function expression, 'TACT(...)'
  - ✓ **Apply the below functions to TraJoint1~TraJoint4 as a joint motion (displacement type)**
  - ✓ **TACT(Actuator1), TACT(Actuator2), TACT(Actuator3), TACT(Actuator4)**
- In this tutorial, the actuators will move 4 shakers below each tire up and down.



RecurDyn/TSG Tutorial (2)

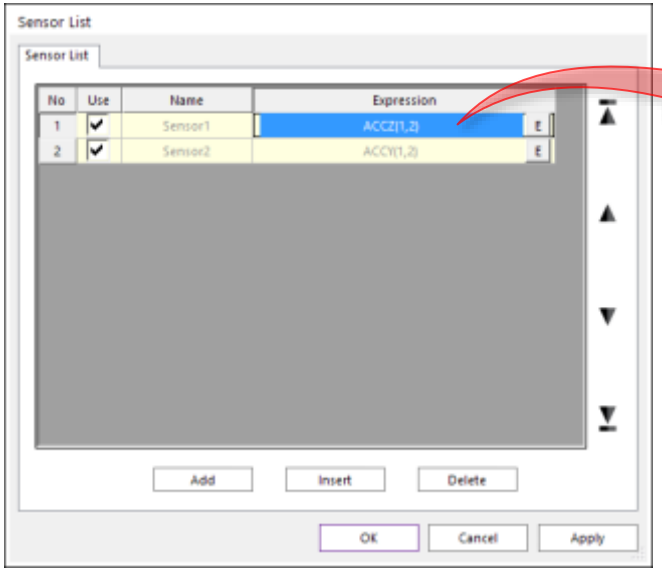
Sensor

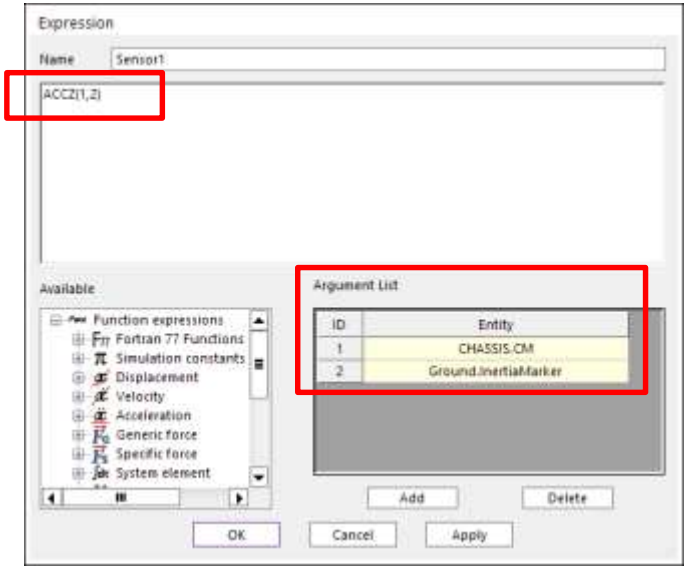
- **Sensor** : The response of the simulation which will be compared with the Target Signal.
  - As shown in the below figure, select **Sensor** icon to open Sensor List Dialog.
  - **Add** 2 sensors in Sensor List dialog.
- **Define the function expressions for the sensors**
  - Any function expression can be used for sensors.
    - ✓ Acceleration(ACCX, ACCY, ACCZ), Velocity(VX, VY, VZ), Disp.(DX, DY, DZ)
    - ✓ Force(FX, FY, FZ, TX, TY, TZ), Stress(SX, SY, SZ), Strain(EX, EY, EZ), Etc.
  - In this tutorial, Z-Acceleration and Y-Acceleration of CM of Chassis will be used.

Sensor1
ACCZ(1, 2)

Sensor2
ACCY(1, 2)

Argument List
1: CHASSIS.CM
2: Ground.InertiaMarker





RecurDyn/TSG Tutorial (3)

Target (1)

- **Target** : User-defined input data.
  - Time-dependent continuous data set measured from experiment or simulation. Performance index of RecurDyn/TSG.
  - After importing measured data, Target data needs to be re-generated. (*.target)
- **Import csv file**
  - *.csv file (text file) is used
  - The number of Target Data in csv file is dependent on the number of Sensors
  - The sequence of the data in csv file must be, *time1, data1, time2, data2, …*
  - In this tutorial, there are 2 sensors, so that 4 data must be written in csv file as shown in the below figure.
    - ✓ Even if the time data is duplicated, it should be written respectively.
    - ✓ The Target Data must be written according to the sequence of the Sensors

time1	data1	time2	data2
0	0	0	0
0.001	-0.0004	0.001	0.000186
0.002	-0.00303	0.002	0.001564
0.003	-0.01027	0.003	0.009046
0.004	-0.02232	0.004	0.033633
0.005	-0.03801	0.005	0.080458
0.006	-0.05629	0.006	0.131874

Target of Sensor1 | Target of Sensor2

RecurDyn/TSG Tutorial (4)

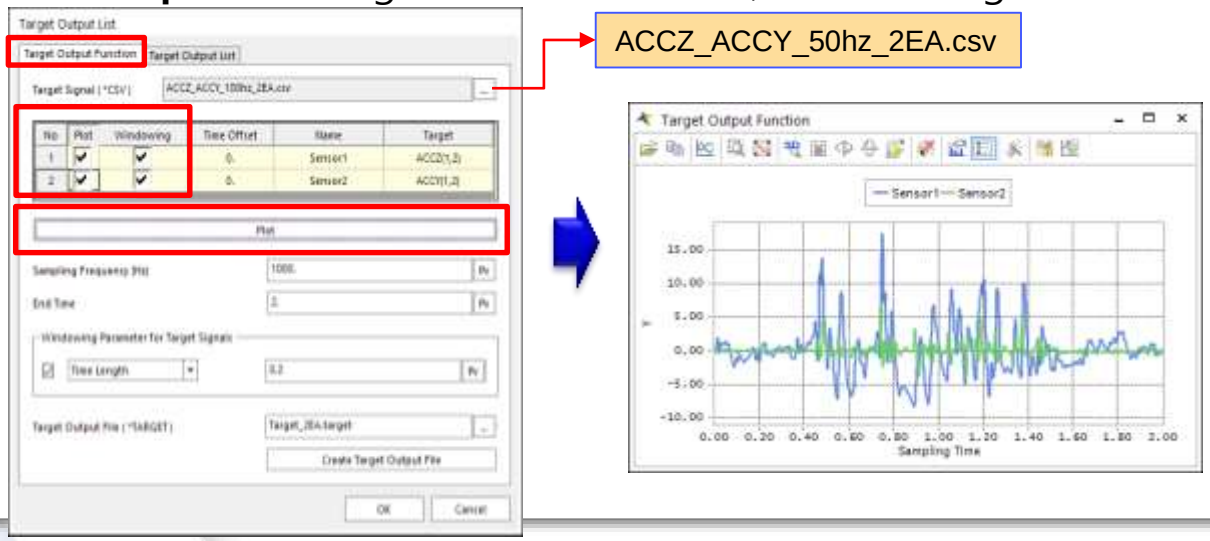
◆ Target (2)

➢ Tips to generate Target Data

- The data measured from experiment usually includes High-frequency data as well as Low-frequency data.
- The high-frequency data can cause noise and error during simulation using TSG.
- So it is recommended to filter the data using Low Pass Filter so that the filtered data can include the signal below 50~100Hz when you generate *.csv file.
  - ✓ You can use Low Pass Filter in RecurDyn/Plot
  - ✓ The sample file of this tutorial, ACCZ_ACCY_50hz_2EA.csv includes the signal below 50Hz.

➢ Import csv file

- Import csv file in '**Target Output Function**' tab of Target Output List dialog
- You can **plot** the Target Data for Sensor1, Sensor2 Target Data.



RecurDyn/TSG Tutorial (5)

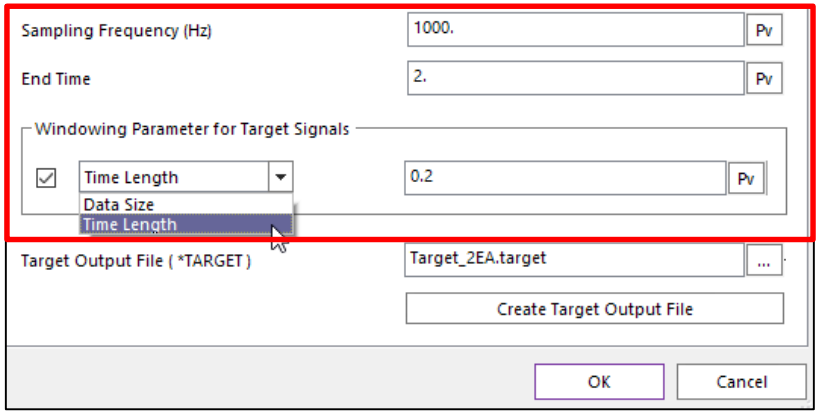
◆ Target (3)

➢ Sampling Frequency

- The number of data per 1 second. 1000 is used in this tutorial.
  - ✓ If Simulation End Time is 2sec, the number of data must be 2000.
- Since the number of data in csv file doesn't match the required number, you must re-generate the data file for the given sampling frequency and end time.
- You will create *.target data in the next page.

➢ Window Parameter for Target Signals

- When the Time Signal is converted to frequency signal using Fourier Transform, the initial signal and the final signal is set to zero to minimize the error.
  - ✓ Windowing is applied about 10% of the entire time,
  - ✓ In this tutorial, 0.2 with Time Length type is used



RecurDyn/TSG Tutorial (6)

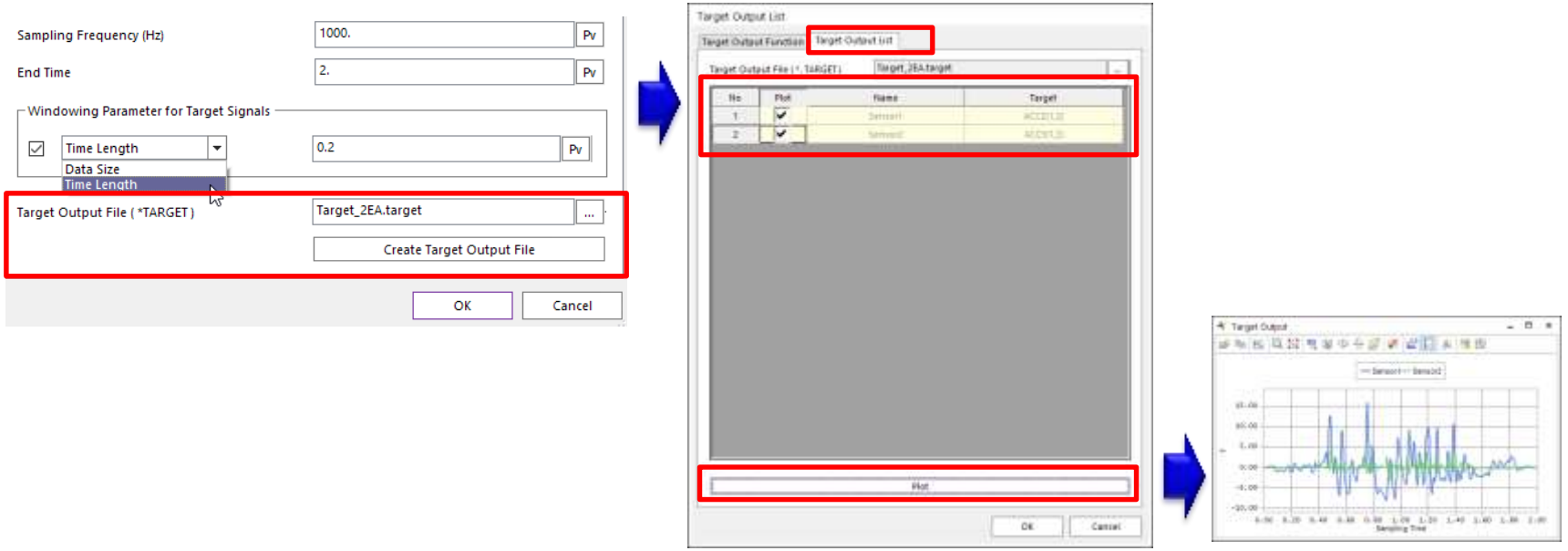
◆ Target (4)

➢ Create Target Data

- Create *.target file from *.csv file based on Sampling Frequency, End Time, Window Parameter.

➢ Create Target Outpuf File

- *.target file is a binary format for better performance.
- After specifying the file name and the path, click **Create Target Output File** button to create *.target.
- Click **Plot** button to plot the data in *.target.



RecurDyn/TSG Tutorial (7)

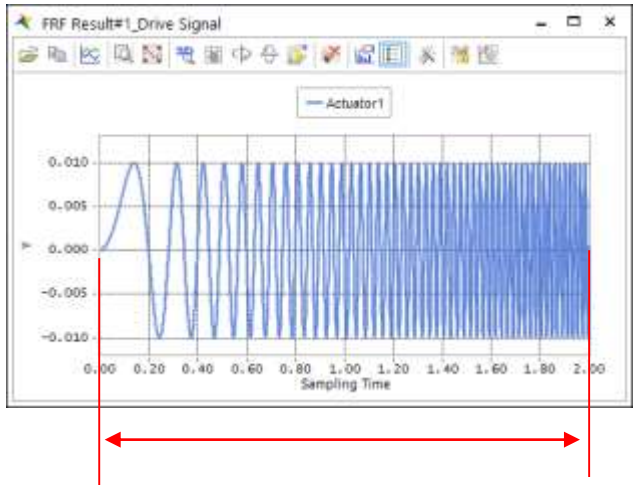
FRF (1)

FRF (Frequency Response Function)

- Computes the linearized model for System Identification (Transfer Function, H(f))

Procedure (1)

- **Start/End Frequency(Hz)**
  - ✓ To perform FRF, the frequency of the signal for actuator ('TACT(Actuator1)') is gradually increased using Sweep Sine Function. Start/End Frequency are for sweep sine function.
  - ✓ Since 0Hz is not valid, **Set Start Frequency** 0.001Hz.
  - ✓ Since the Target Signal is the data below 50Hz, set **End Frequency** 50Hz.

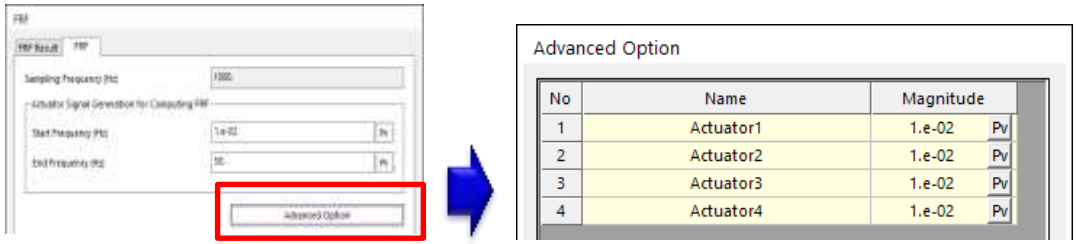


RecurDyn/TSG Tutorial (8)

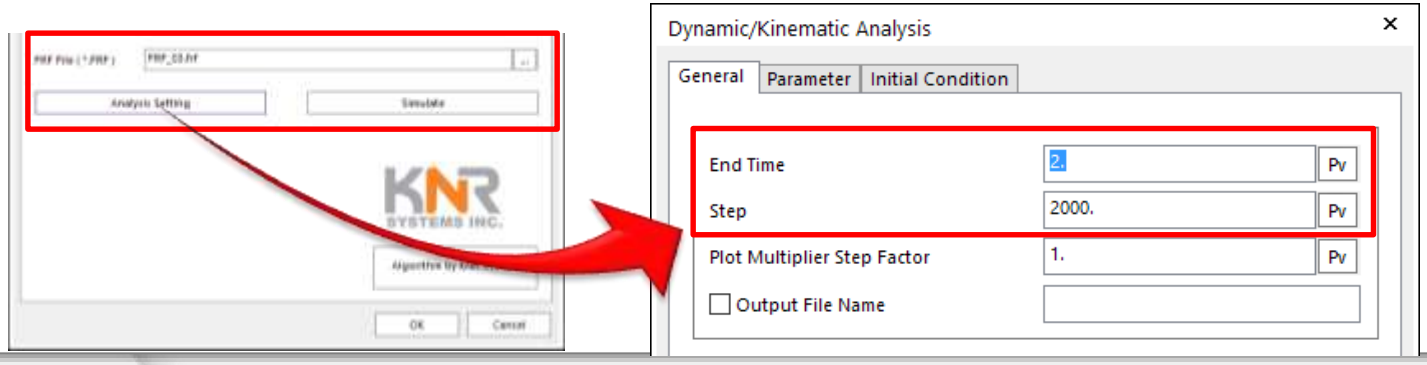
FRF (2)

Procedure (2)

- Set Magnitude of Sweep Sine Function in **Advanced Option**.
  - ✓ The model in this tutorial uses MKS unit, Magnitude = 1 means, the displacement of the tire is 1m. It is too excessive condition.
  - ✓ Set All the **Magnitudes** 0.01.



- Specify the file name and path for FRF result.
- Adjust **Analysis Setting for** Dynamic Analysis, then click **Simulation** button.
  - ✓ End Time and Step must be consistent with the Sampling Frequency.
  - ✓ Since the Sampling Frequency in this tutorial is 1000Hz,
  - ✓ Set **End Time = 2sec, and Step = 2000.**

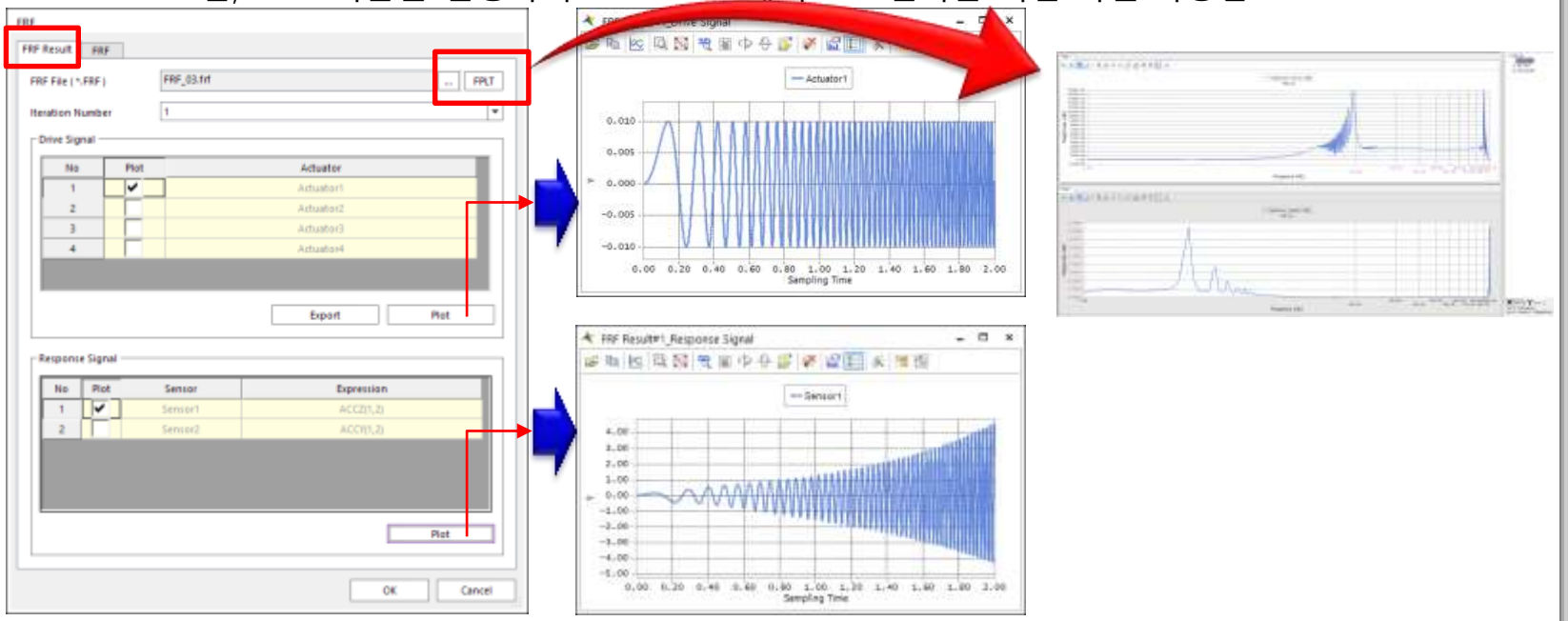


RecurDyn/TSG Tutorial (9)

FRF (3)

Procedure (3)

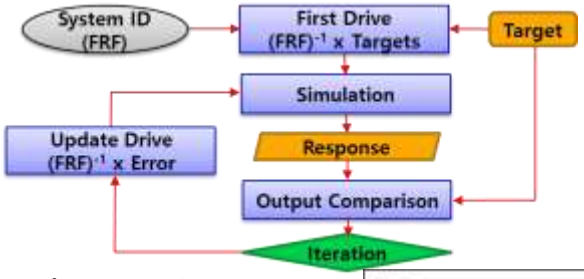
- After you click **Simulation** button, the simulation is performed as the number of actuators.
  - ✓ In this tutorial 4 simulations are performed.
  - ✓ When Sweep Sine Function is applied to an Actuator during FRF, when one actuator is driven, the other actuators are set 0.
- After simulation, You can **Plot** the **Drive Signal** (Sweep Sine Function) of the actuators **and Response Signal** of the sensors in FRF Result tab.
  - ✓ 또한, FPLT 버튼을 실행하여 Plot Mode에서 FRF 결과를 직접 확인 가능함.



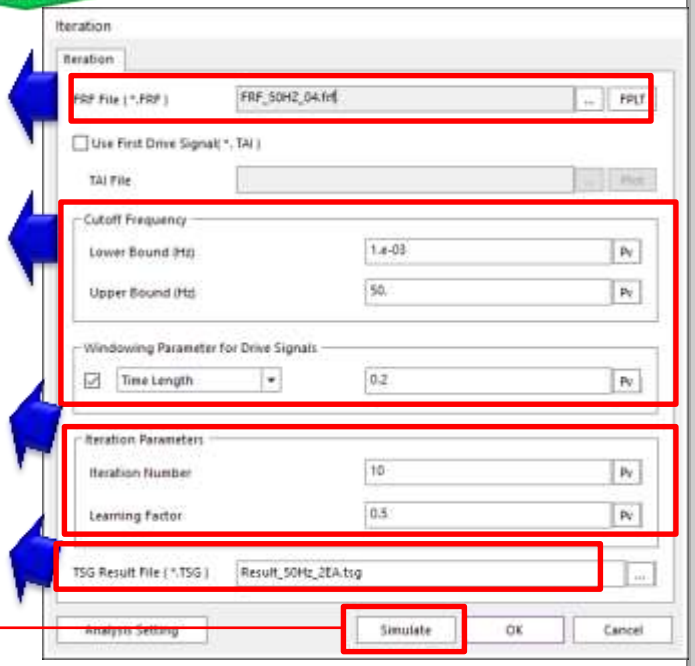
RecurDyn/TSG Tutorial (10)

Iteration

- **Iteration**: performs the **iterative simulation** to find the **Drive Signal** applied to Actuator to match the **Response Signal** of sensor and **Target Signal** as much as possible using FRF result.



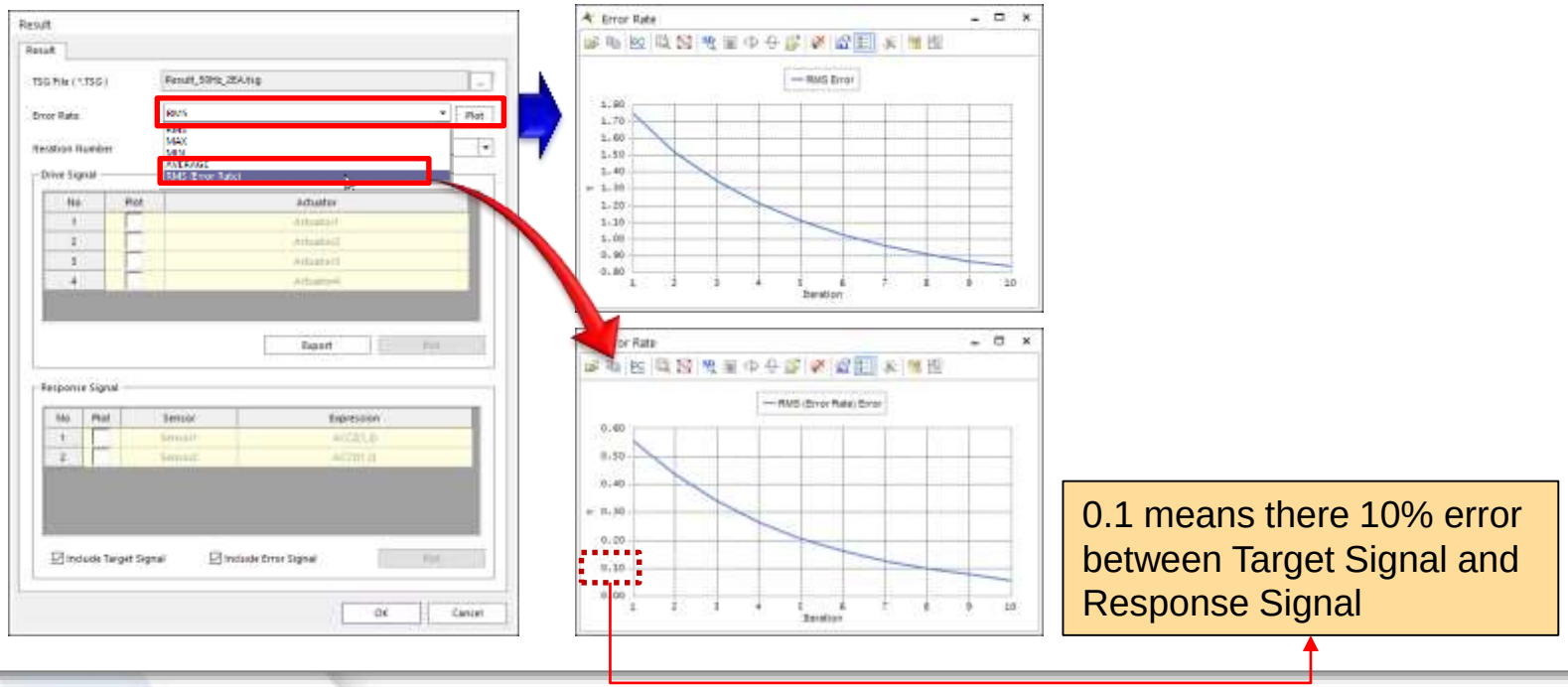
- Procedure
  - **FRF file:** FRF result calculated in the previous step is set automatically. Or you can specify *.frf file.
  - **Cutoff Frequency and Windowing Parameters:** Use the same values used during FRF, for Cutoff Frequency, Windowing Parameter. (0.001, 50)
  - **Iteration Parameters:** Set Iteration Number = 10 and use the default value for Learning Factor (0.5)
  - **TSG Result File:** Specify the file name and path to save the TSG Results.
  - Click **Simulate** button.



RecurDyn/TSG Tutorial (11)

Result (1)

- Post-processor of TSG to review the result in *.tsg after iterative simulation.
  - **Error Rate (RMS)**: For each iteration, the RMS of the difference between Response Signal (Sensor) and Target Signal at every instant
  - **Error Rate (RMS (Error Rate))** : the relative difference the RMS of Target Signal for entire time and the RMS of Response Signal (Sensor) for entire time
- Procedure (1)
  - **Specify** the **type of Error Rate** and click **Plot** button to review the error rate of each iteration.

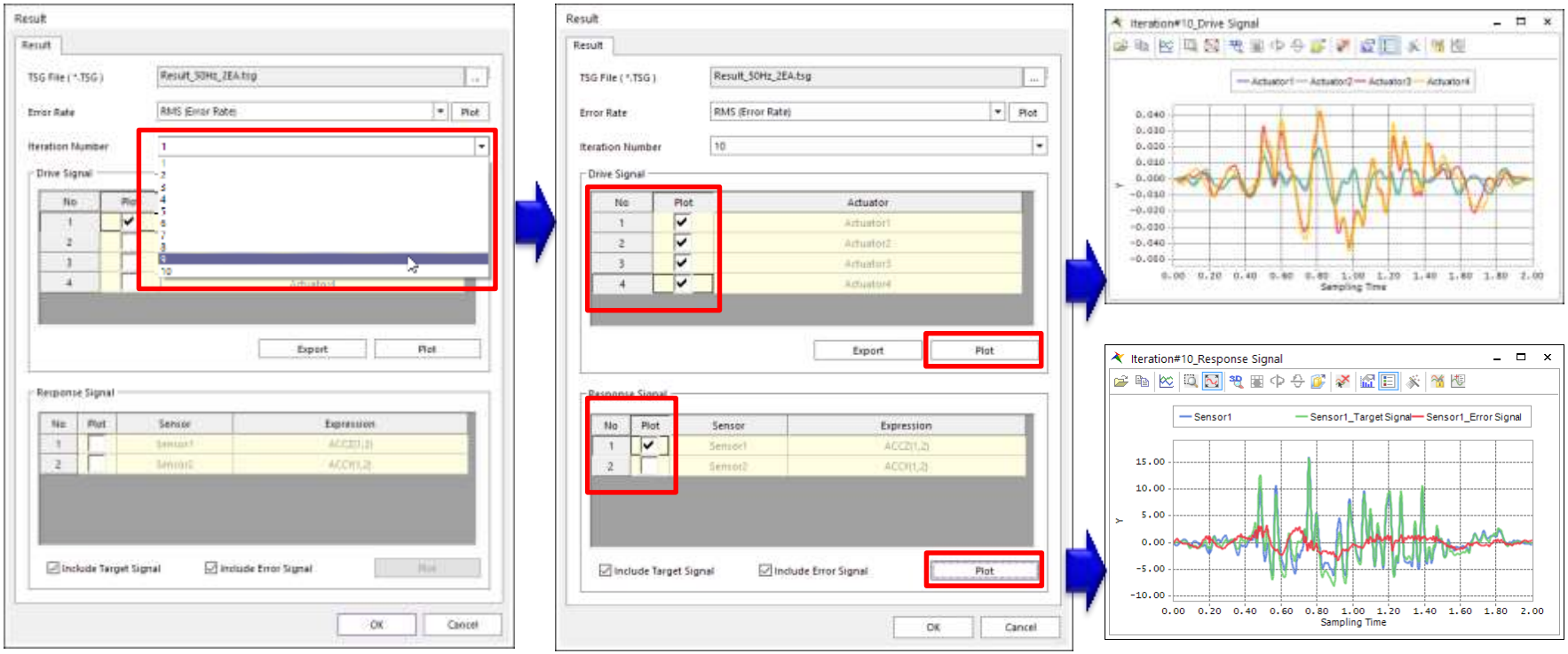


RecurDyn/TSG Tutorial (12)

Result (2)

Procedure (2)

- Select the desired Iteration Number
- **Plot** the Drive Signal of the selected actuators and Response Signal of the selected Sensors.

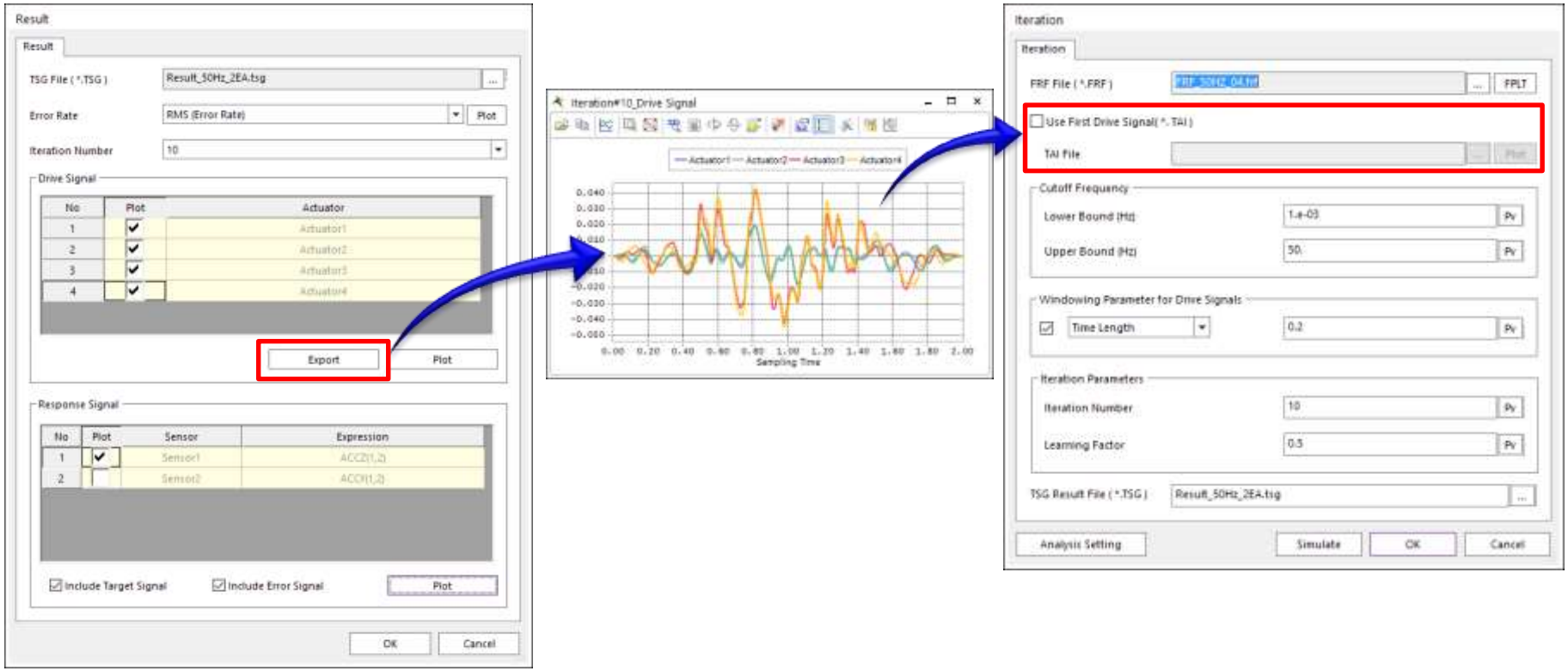


RecurDyn/TSG Tutorial (13)

◆ Result (3)

➢ Procedure (3)

- You can export all Drive Signal of the selected Iteration Number as ***.tai file.**
  - ✓ tai file can be used to perform **additional iteration** after 10 iteration already performed.
  - ✓ In Iteration dialog, check '**Use First Drive Signal**' and **specify** *.tai file.

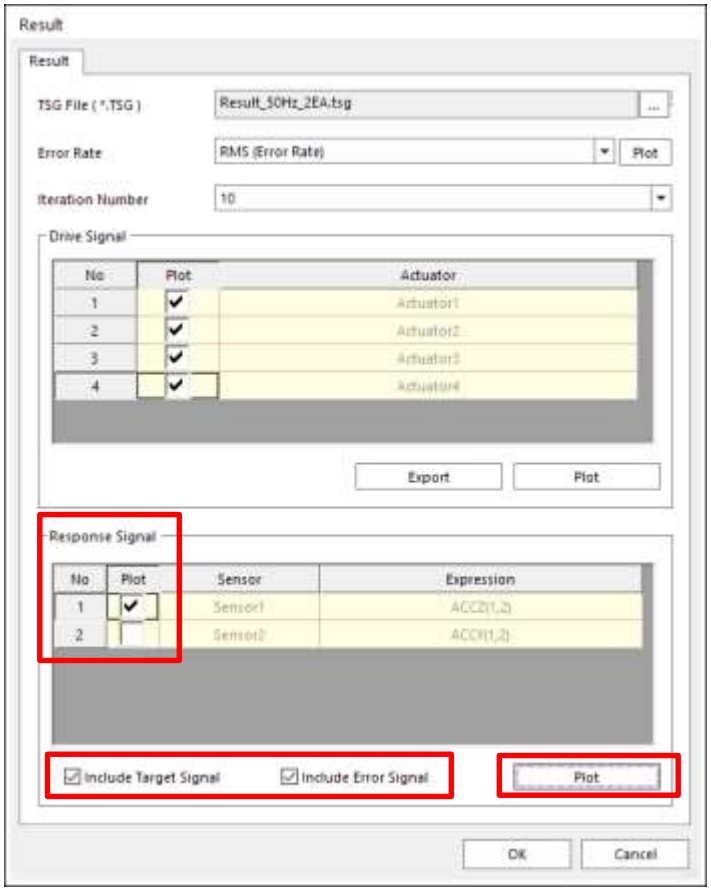


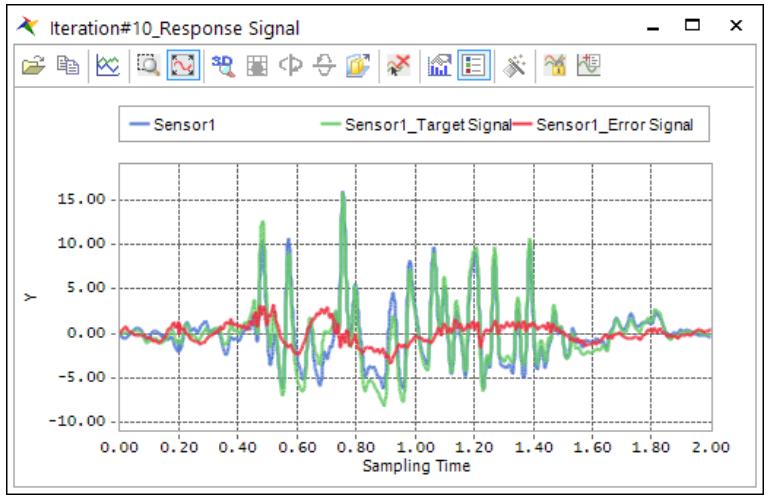
RecurDyn/TSG Tutorial (14)

Result (4)

Procedure (4)

- When you plot Sensor data in 'Response Signal'
  - ✓ You can plot Target Signal or Error Signal as well as the output of Sensor
  - ✓ You can use the option, '**Include Target Signal**' and '**Include Error Signal**'

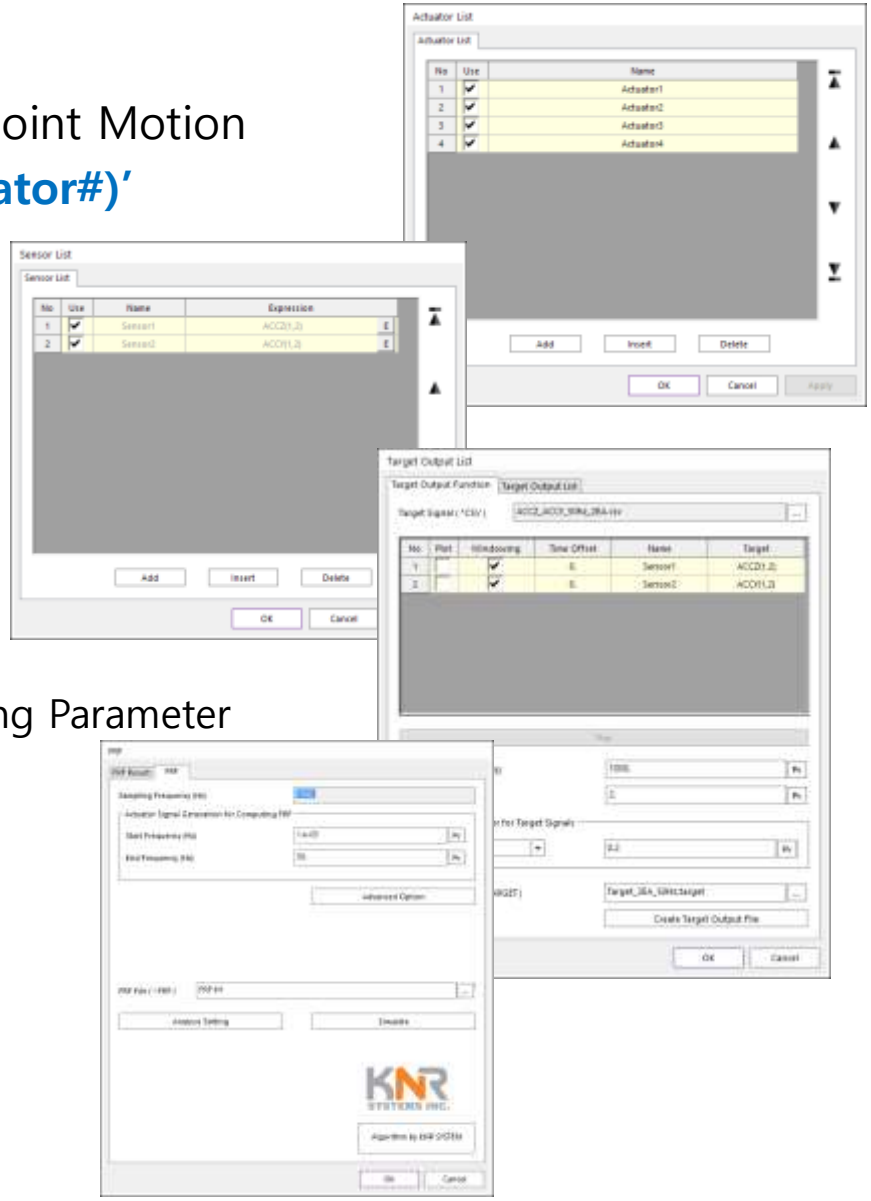




Summary of RecurDyn/TSG Tutorial

Summary of RecurDyn/TSG Tutorial (1)

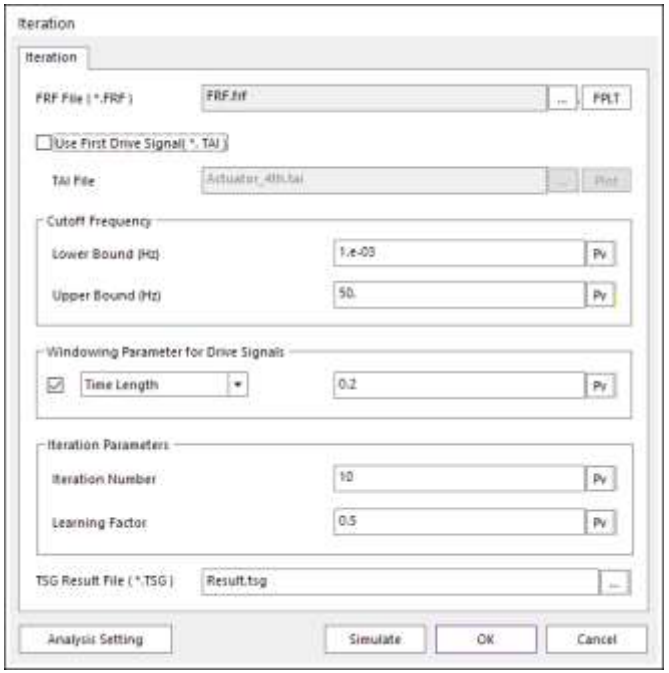
- **Create Actuator**
  - Add 4 Actuators and apply it to Joint Motion
  - **Translational Joint : 'TACT(Actuator#)'**
- **Create Sensor**
  - Add 2 Sensors
    - Sensor1 ➔ ACCZ(1,2)
    - Sensor2 ➔ ACCY(1,2)
- **Create Target Signal**
  - Import *.csv File
  - Create *.target File
    - Set Sampling Frequency, Windowing Parameter
- **Create FRF**
  - Create *.frf File
    - Start/End Frequency
    - Advanced Option
  - 4 simulations
  - Review the result of FRF, FRF^{-1}



Summary of RecurDyn/TSG Tutorial (2)

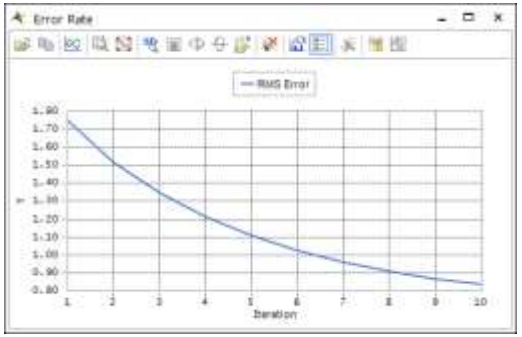
Iteration

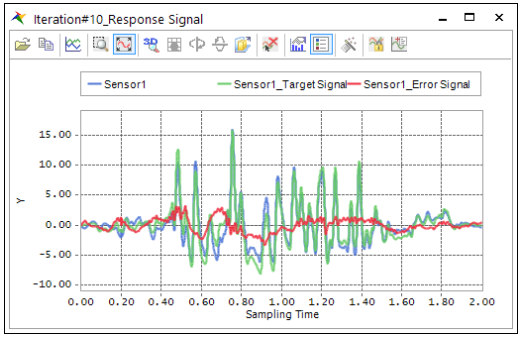
- Import FRF
- Specify options
  - Cutoff Frequency
  - Window Parameter
  - Iteration Parameter
- Create *.tsg File
  - 10 iterative simulations



Result

- Review Error Rate (RMS)
- Review Drive/Response Signal





Thank you

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