



# RecurDyn/TSG Tutorial

**Yongwoo JUN**

---

FunctionBay Solution Group

# RecurDyn/TSG Tutorial (1)

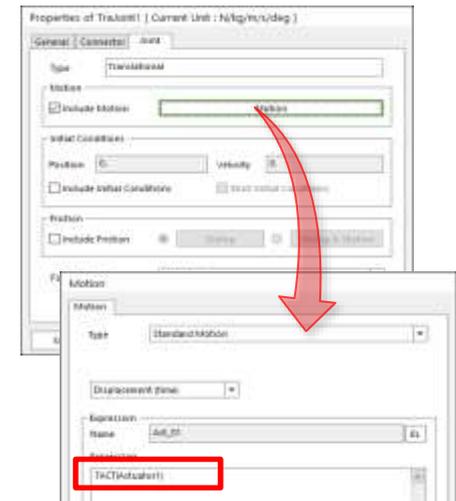
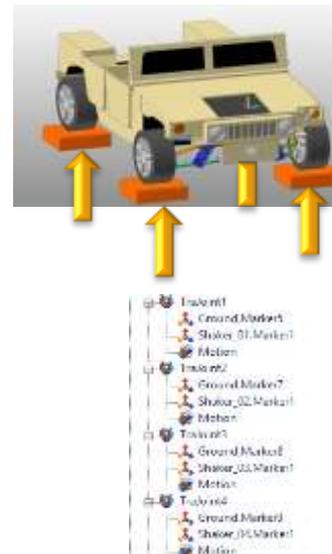
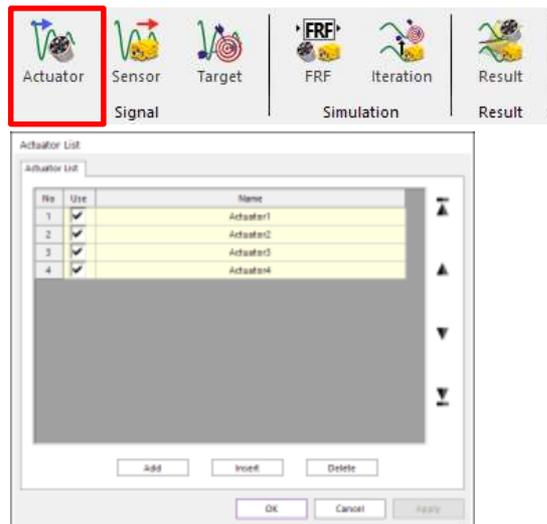
## ◆ Actuator

### ➤ 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 Joint 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

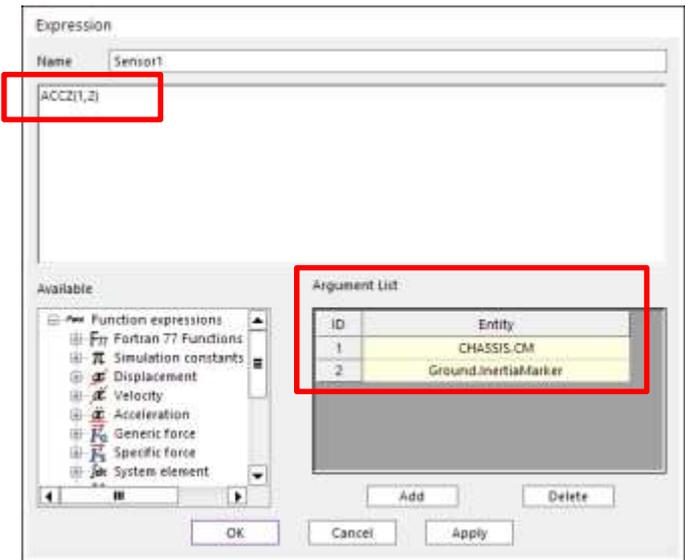
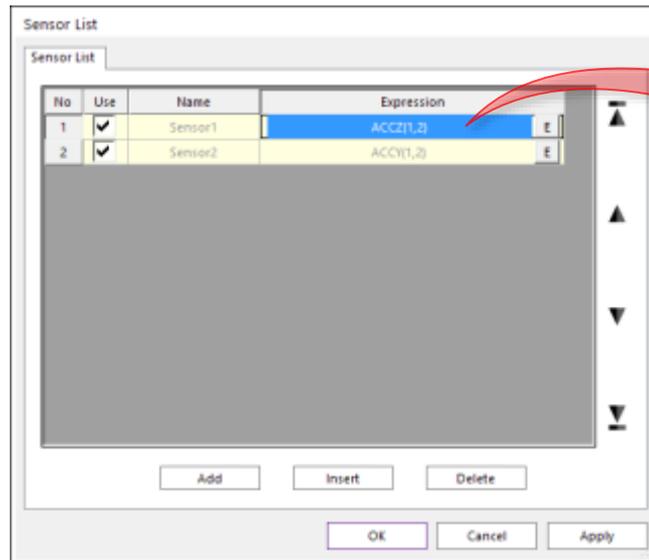


- **Sensor** : The response of the simulation which will be compared with the Target Signal.
  - As shown in the below figure, select **Sensor** icon to open Sensor List Dialog.
  - **Add** 2 sensors in Sensor List dialog.
- **Define the function expressions for the sensors**
  - Any function expression 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.

The image shows two windows from the RecurDyn software. The left window is the 'Target Output List' dialog, and the right window is the 'Target Output Function' plot.

**Target Output List Dialog:**

- The 'Target Output Function' tab is selected.
- The 'Target Signal (\*CSV)' field contains 'ACCZ\_ACCY\_100hz\_2EA.csv'.
- A table lists two target signals:

No.	Plot	Windowing	Time Offset	Name	Target
1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.	Sensor1	ACCZ(,3)
2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	0.	Sensor2	ACCY(,2)

Below the table, the 'Plot' checkbox is checked. Other settings include 'Sampling Frequency Plot' (1000 Hz), 'End Time' (2), and 'Windowing Parameter for Target Signal' (Time Length: 0.2).

**Target Output Function Plot:**

- The plot shows two signals: Sensor1 (blue) and Sensor2 (green).
- The x-axis is 'Sampling Time' from 0.00 to 2.00.
- The y-axis ranges from -10.00 to 15.00.
- The plot shows high-frequency oscillations for both sensors, with Sensor1 having a higher amplitude than Sensor2.

A red box highlights the 'Target Output Function' tab and the 'Plot' checkbox in the dialog. A blue arrow points from the dialog to the plot window. A yellow box highlights the file name 'ACCZ\_ACCY\_50hz\_2EA.csv' with a red arrow pointing to the 'Target Signal' field.

# 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

Sampling Frequency (Hz) 1000. Pv

End Time 2. Pv

Windowing Parameter for Target Signals

Time Length 0.2 Pv

Data Size

Time Length

Target Output File (\*TARGET) Target\_2EA.target ...

Create Target Output File

OK Cancel

# 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 Output 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.

Sampling Frequency (Hz)  Pv

End Time  Pv

Windowing Parameter for Target Signals

Time Length  Pv

Data Size

Time Length

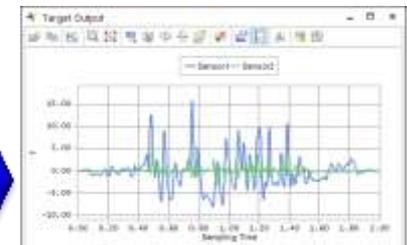
Target Output File (\*TARGET)  ...



Target Output List

Target Output Function:

No.	Plot	Name	Target
1.	<input checked="" type="checkbox"/>	Default	ACCEL10
2.	<input checked="" type="checkbox"/>	Sensor1	ACCEL10



# RecurDyn/TSG Tutorial (7)

## ◆ FRF (1)

### ➤ FRF (Frequency Response Function)

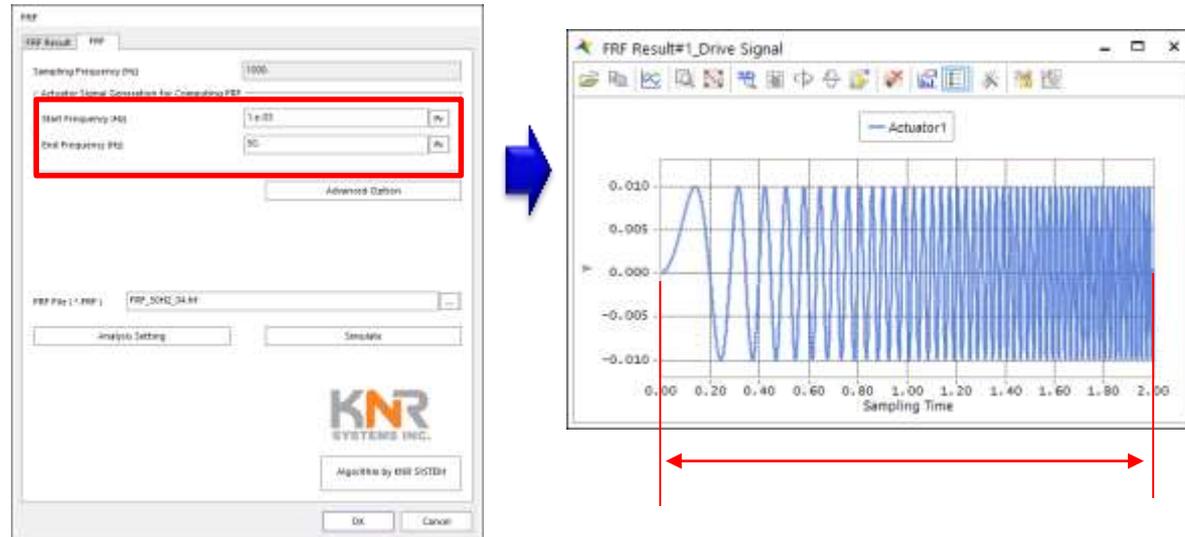
- Computes the linearized model for System Identification (Transfer Function,  $H(f)$ )



### ➤ 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.

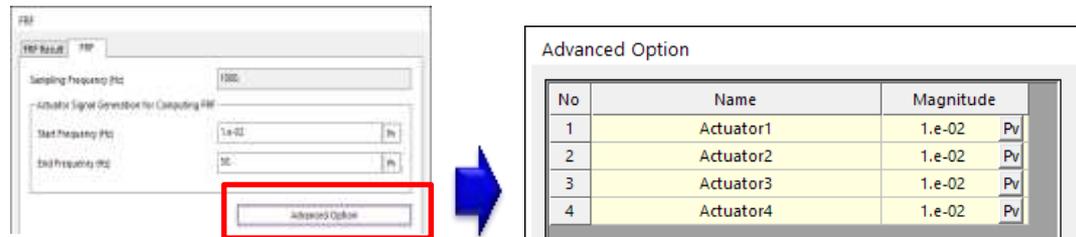


# RecurDyn/TSG Tutorial (8)

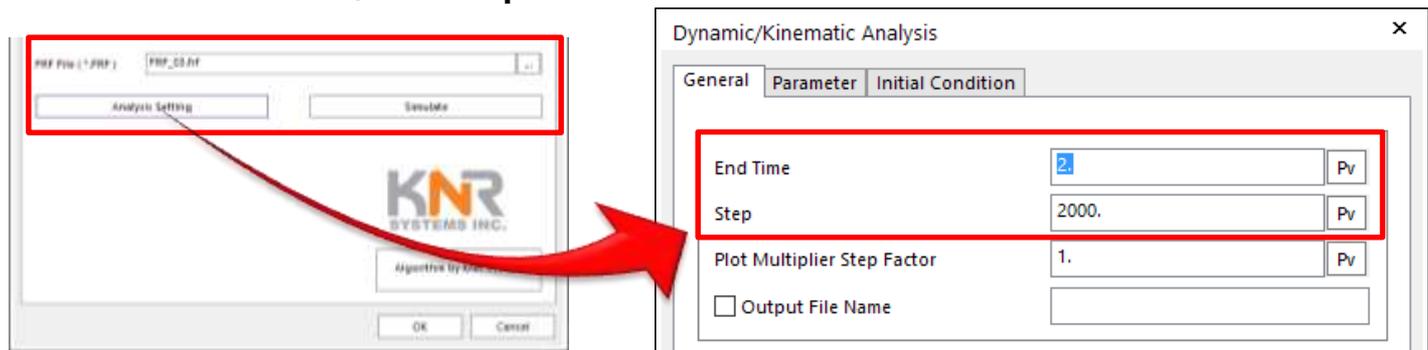
## ◆ FRF (2)

### ➤ 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**.

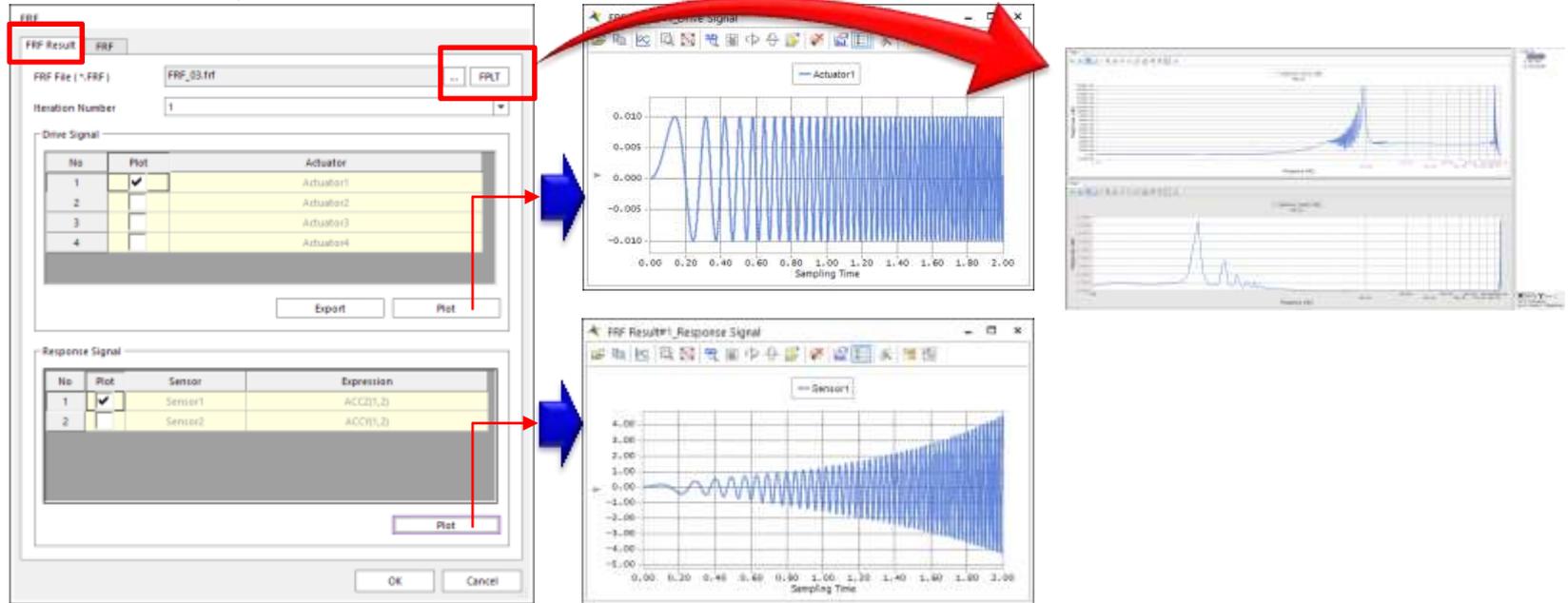


# RecurDyn/TSG Tutorial (9)

## ◆ FRF (3)

### ➤ Procedure (3)

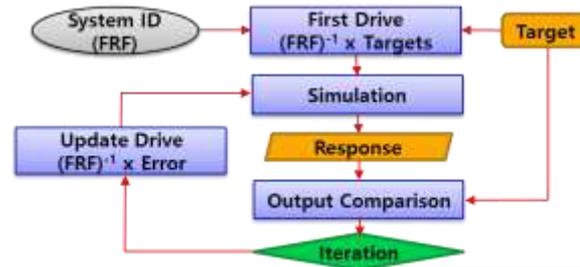
- After you click **Simulation** button, the simulation is performed as the number of actuators.
  - ✓ In this tutorial 4 simulations are performed.
  - ✓ When Sweep Sine Function is applied to an Actuator during FRF, when one actuator is driven, the other actuators are set 0.
- After simulation, You 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)

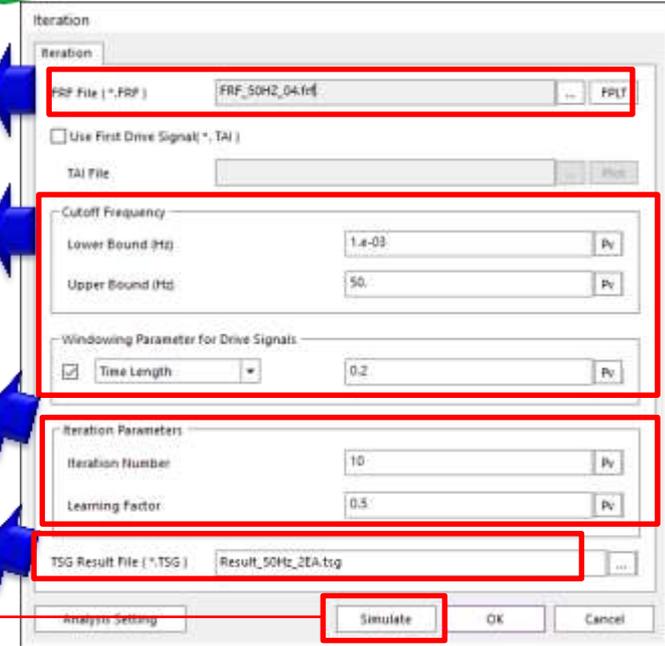
## ◆ Iteration

- **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.

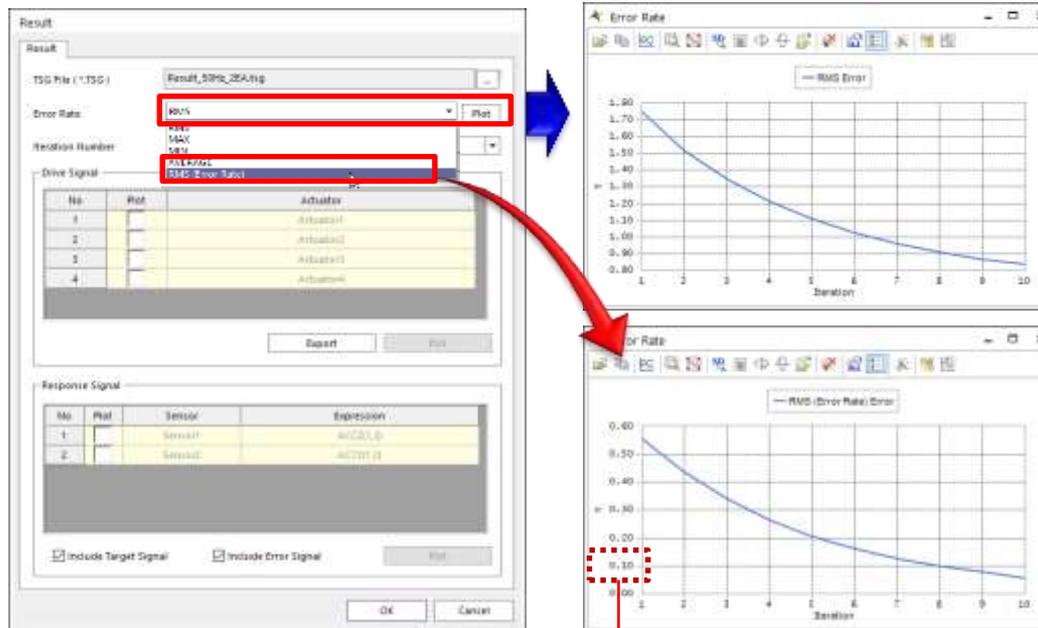


# RecurDyn/TSG Tutorial (11)

## ◆ 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.



0.1 means there 10% error between Target Signal and Response Signal

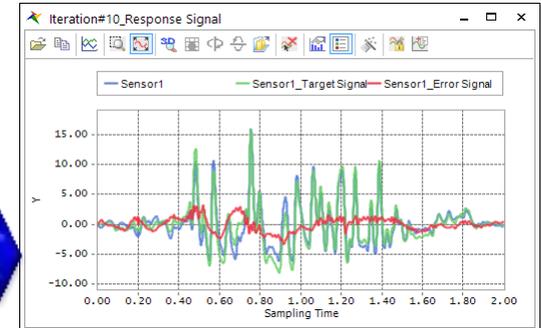
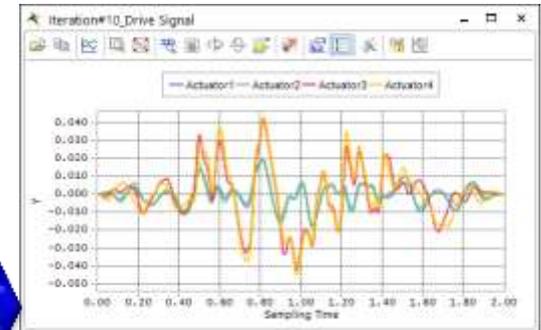
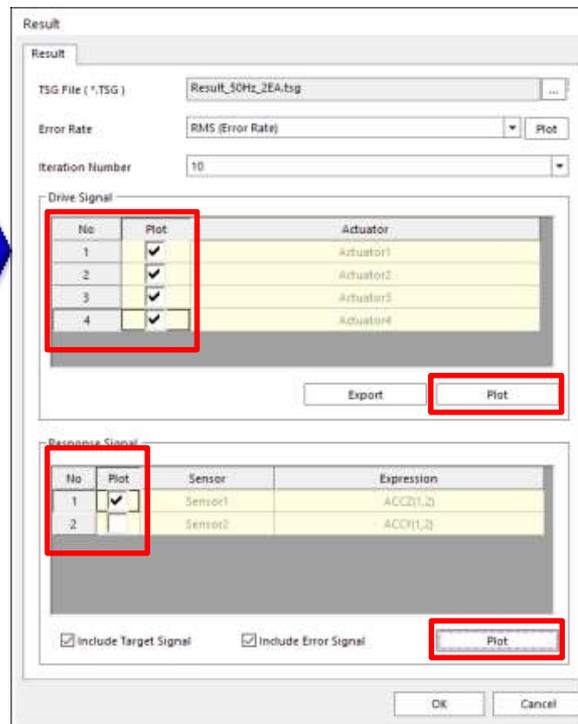
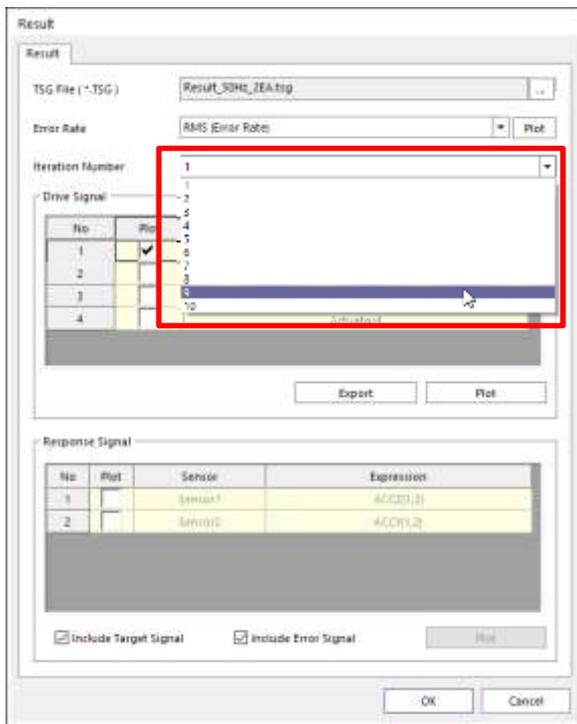


# RecurDyn/TSG Tutorial (12)

## ◆ 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**.

The image shows three windows from the software interface:

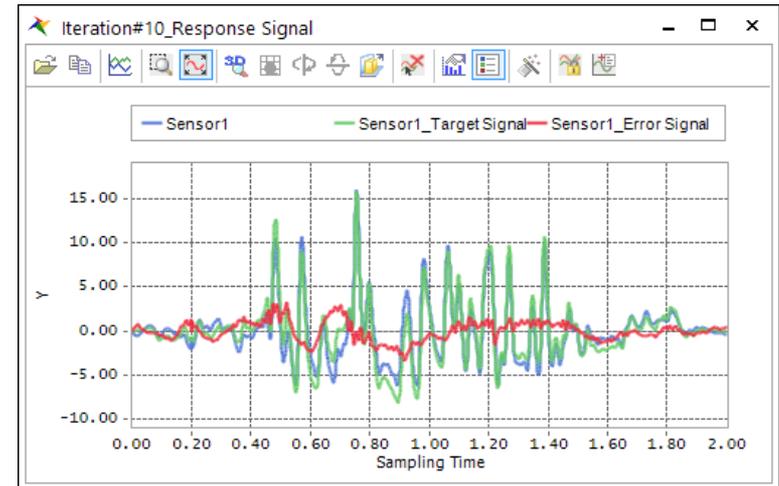
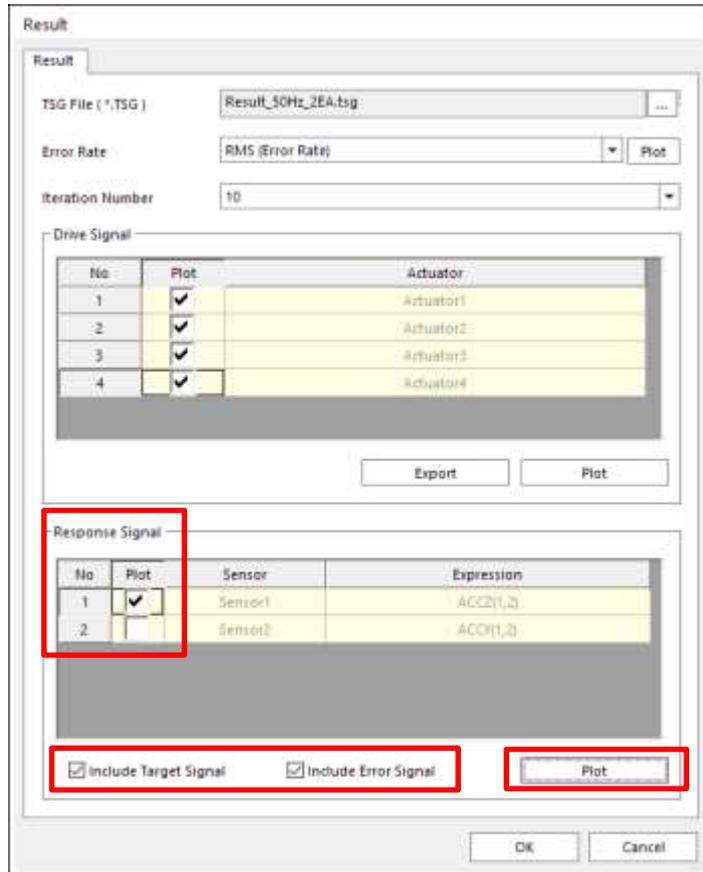
- Result Dialog:** Shows 'TSG File' as 'Result\_50Hz\_2EA.tsg', 'Error Rate' as 'RMS (Error Rate)', and 'Iteration Number' as '10'. The 'Drive Signal' table has four rows for Actuator1-4, all with 'Plot' checked. The 'Export' button is highlighted with a red box.
- Iteration#10\_Drive Signal Plot:** A line graph showing four oscillating signals (Actuator1-4) over a 'Sampling Time' from 0.00 to 2.00. The y-axis ranges from -0.050 to 0.040.
- Iteration Dialog:** Shows 'FRF File' as 'FRF\_50Hz\_04.fr'. The 'Use First Drive Signal (\*.TAI)' checkbox is highlighted with a red box. Below it is a 'TAI File' field. Other settings include 'Cutoff Frequency' (Lower Bound: 1.4-03, Upper Bound: 50), 'Windowing Parameter for Drive Signals' (Time Length: 0.2), and 'Iteration Parameters' (Iteration Number: 10, Learning Factor: 0.5). The 'TSG Result File' is 'Result\_50Hz\_2EA.tsg'. Buttons for 'Analysis Setting', 'Simulate', 'OK', and 'Cancel' are at the bottom.

# 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

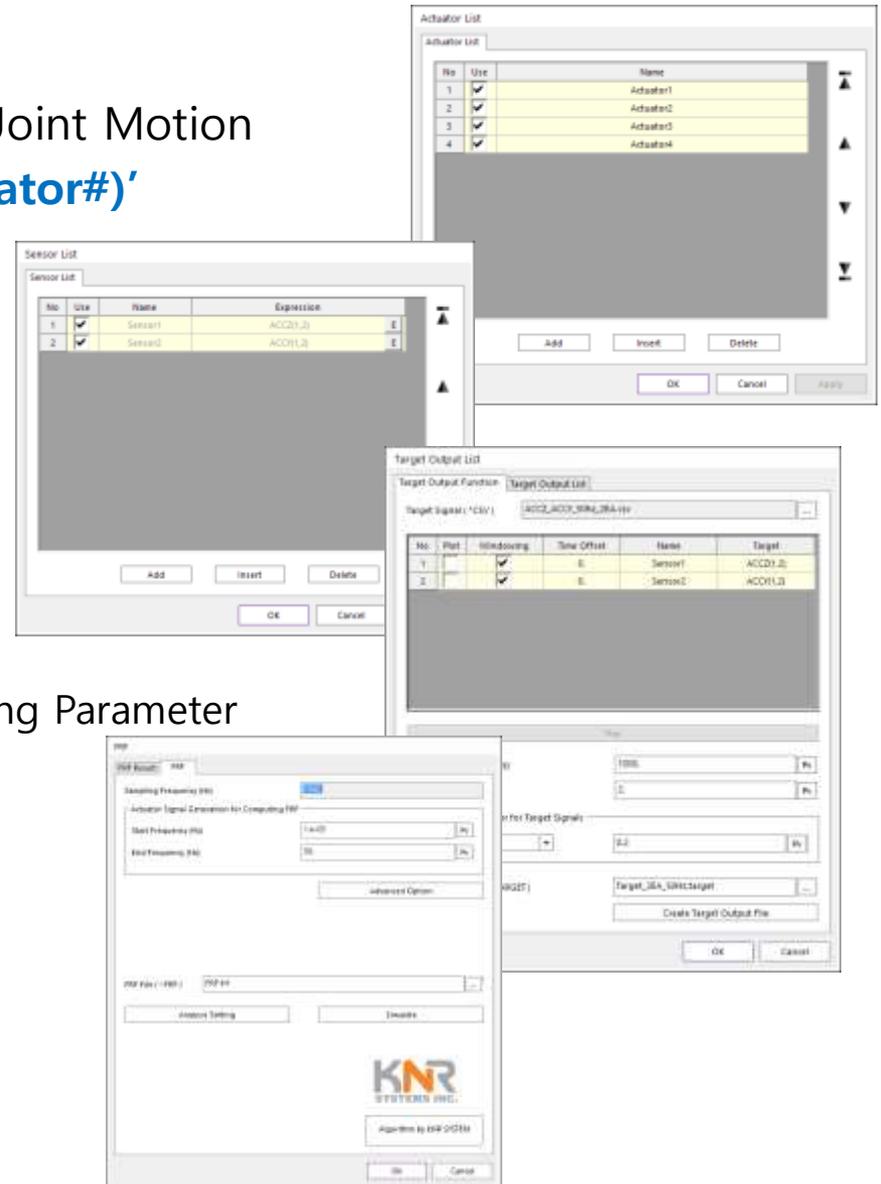
- Add 2 Sensors
  - Sensor1 → ACCZ(1,2)
  - Sensor2 → ACCY(1,2)

## ◆ Create Target Signal

- Import \*.csv File
- Create \*.target File
  - Set Sampling Frequency, Windowing Parameter

## ◆ Create FRF

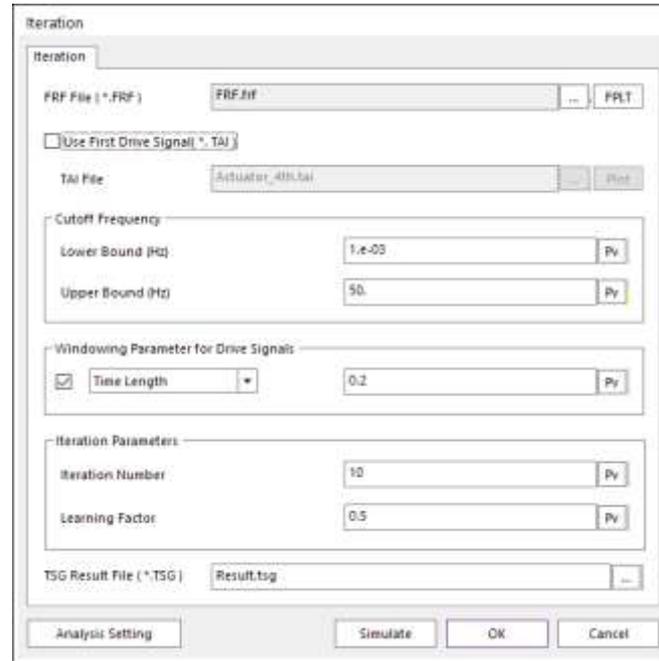
- Create \*.frf File
  - Start/End Frequency
  - Advanced Option
- 4 simulations
- Review the result of FRF, FRF-1



# Summary of RecurDyn/TSG Tutorial (2)

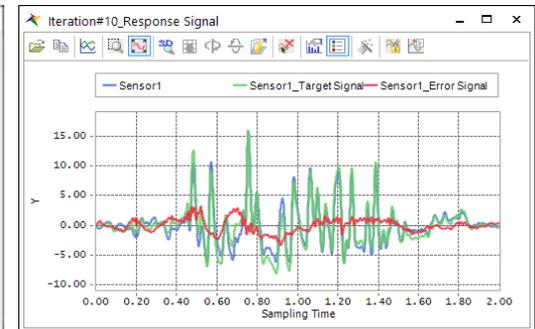
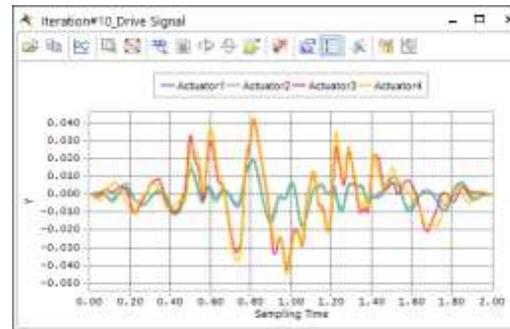
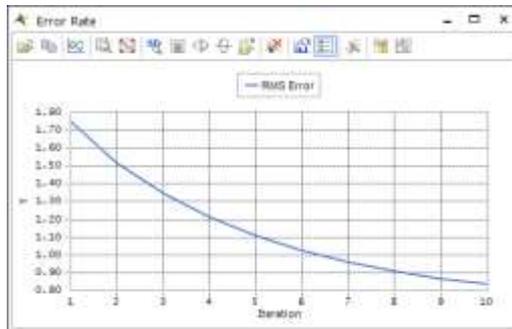
## ◆ Iteration

- 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

5F, Pangyo Seven Venture Valley 1 danji 2dong, 15, Pangyo-ro 228beon-gil,  
Bundang-gu, Seongnam-si, Gyeonggi-do, 13487, Korea  
Tel : +82-31-622-3700, Fax +82-31-622-3704, <http://www.functionbay.co.kr>