# Hand-On Model Physical System in Various fidelity level Workshop

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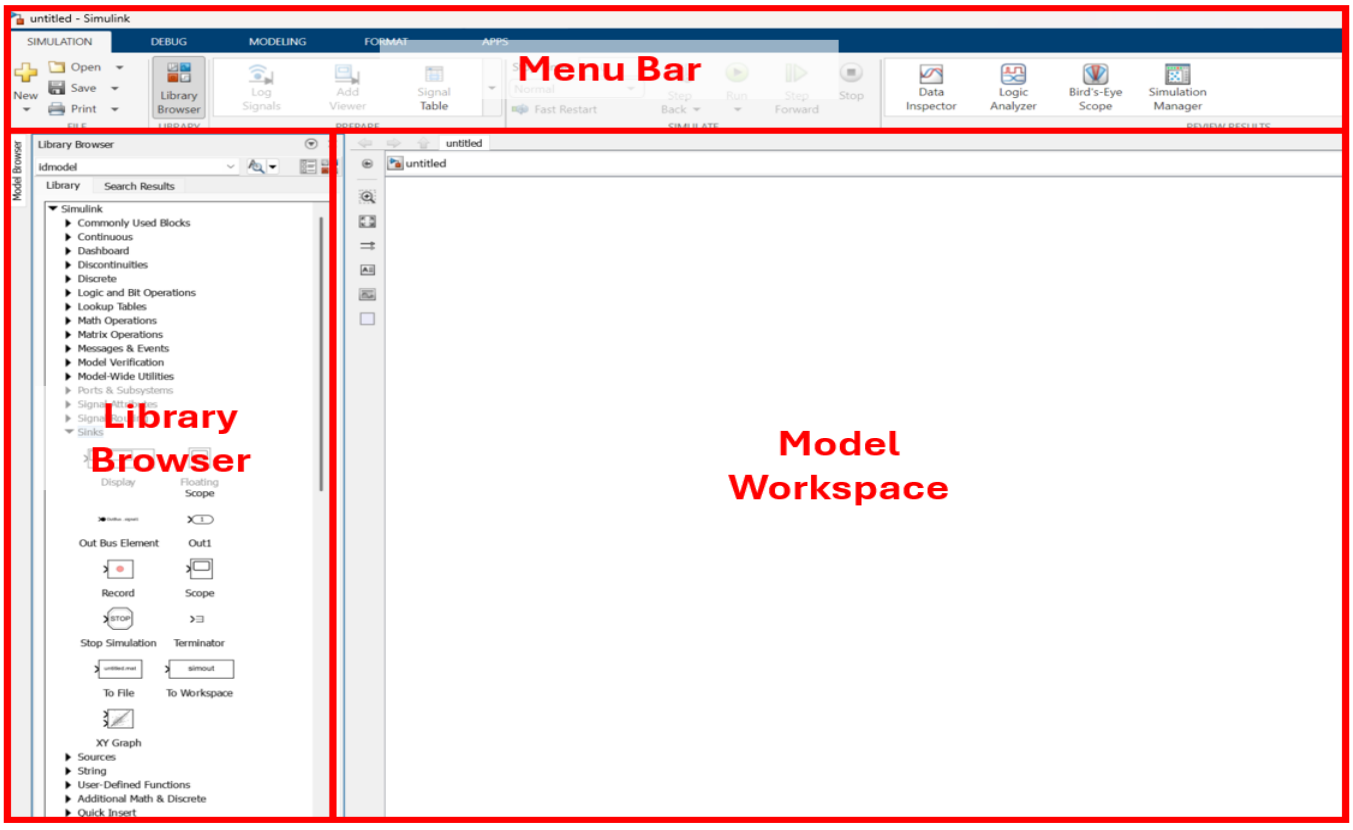
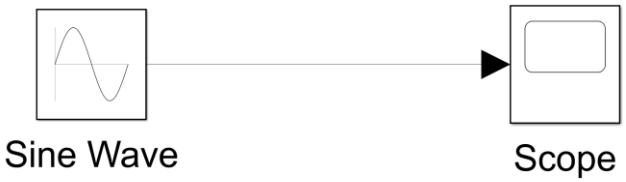
## Introduction to Simulink

### Simulink

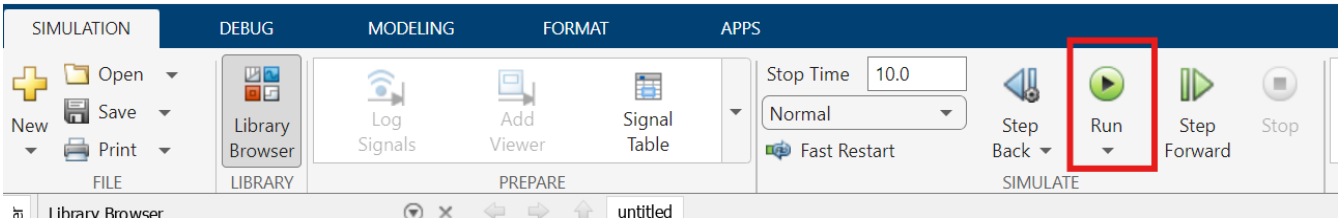


## Task 0-1: Simulink block and Simulation

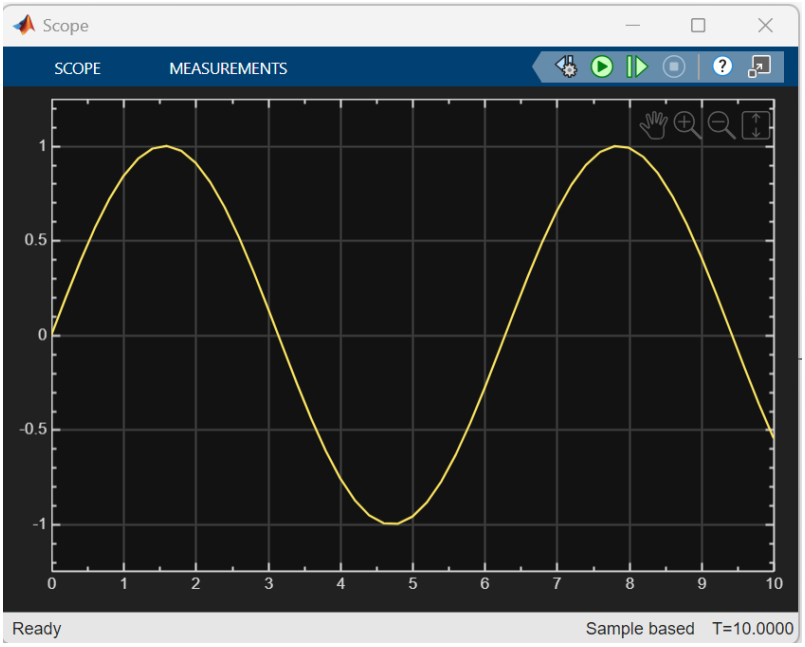
- Drag and Drop "**Sine Wave**" block from "**Simulink>Sources**" to the workspace
- Drag and Drop "**Scope**" block from "**Simulink>Sink**" to the workspace
- Connect the signal from "**Sine Wave**" to "**Scope**"




- Start simulating the system by clicking "**Run**" at Simulate section

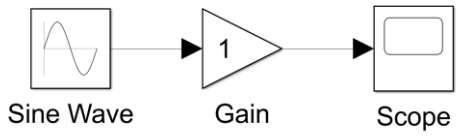



- Check the output by double click at "**Scope**"

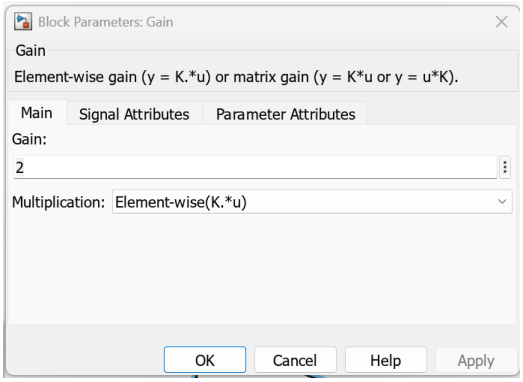


## Task 0-2: Math calculation

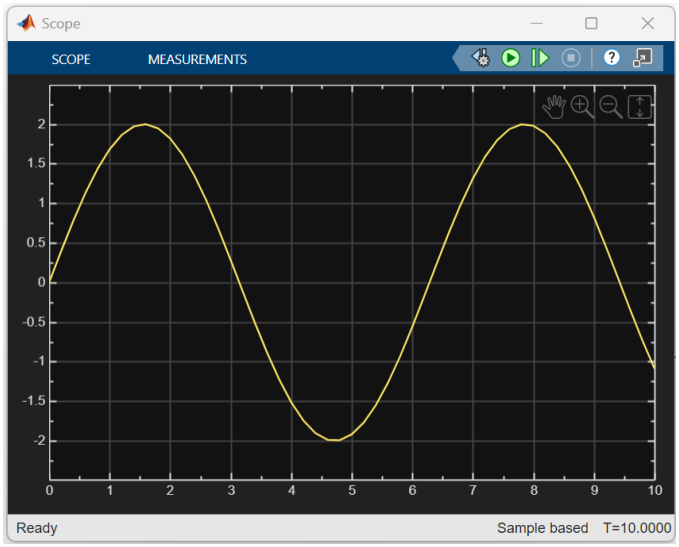
- Drag and Drop "**Gain**" block from "**Simulink>Math Operations**" to the workspace
- Place the "**Gain**" block in the signal line between "**Sine Wave**" and "**Scope**" block




- Double clicks at "Gain" block and change the gain value to 2

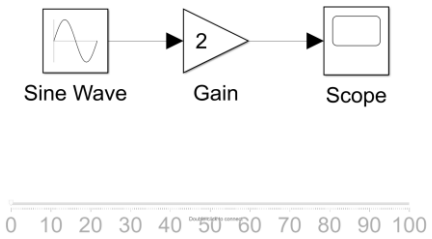



- Start simulating the system by clicking "**Run**" at Simulate section
- Check the output by double click at "**Scope**"

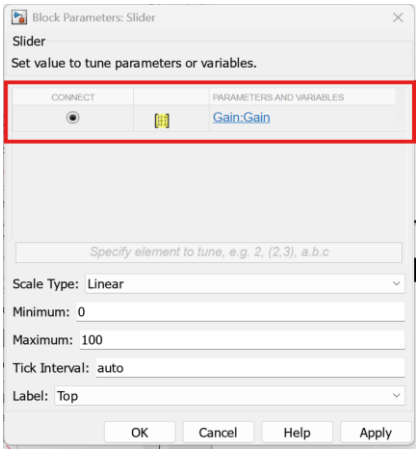


## Task 0-3: Dashboard control

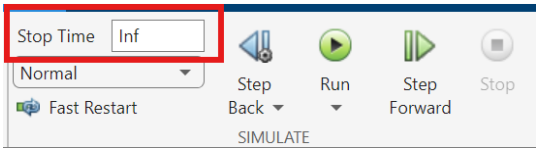
- Drag and Drop "**Slider**" block from "**Simulink>Dashboard**" to the workspace



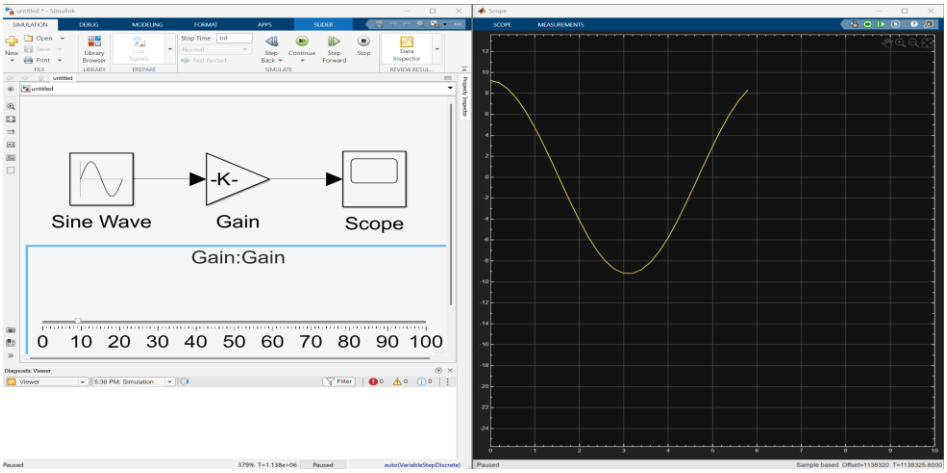

- Double clicks at "**Slider**" --> Select "**Gain**" block --> Click at "**Connect**" check of the gain value --> Click "**OK**" to confirm



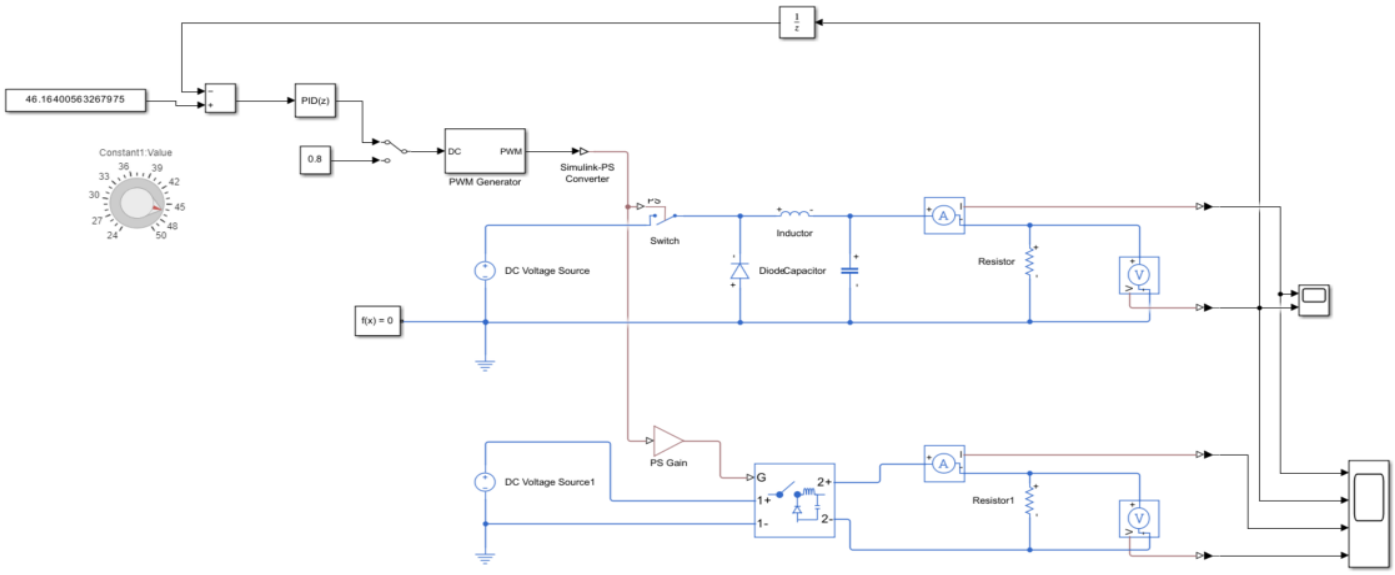

- Change "**Stop Time**" to "**Inf**"




- Try to Slide the "**Slider**" bar and see the changed of Sine Wave at "**Scope**"



# Model Physical System in various fidelity level




## Task 1: Create fundamental Buck converter circuit

1. Drag the block from

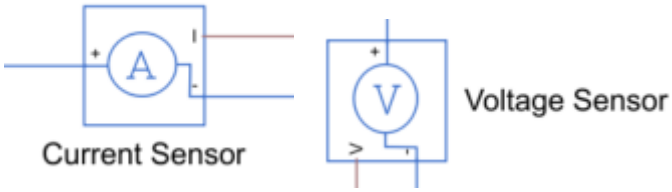
**Simscape>Foundation Library>Electrical Sources**


**Simscape>Foundation Library>Electrical Element**

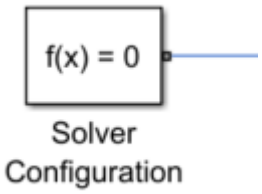

Component Values

$$R = 1\,\Omega, \quad L = 3\,\text{mH} = 3 \times 10^{-3}\,\text{H}, \quad C = 10\,\mu\text{F} = 10 \times 10^{-6}\,\text{F}$$

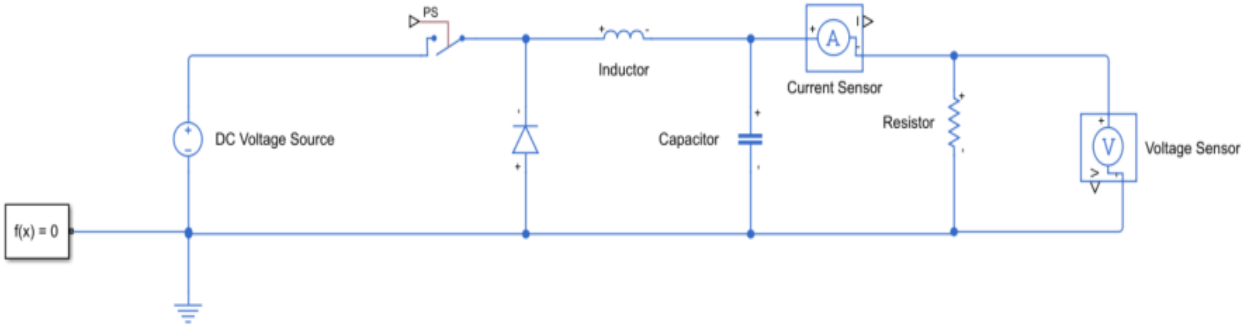
**Simscape>Foundation Library>Electrical Sensor**



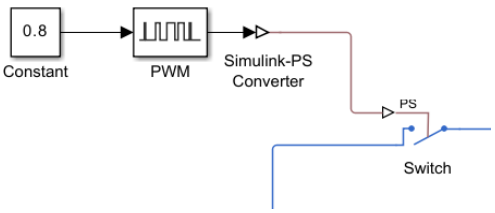
**Simscape>Utilities**

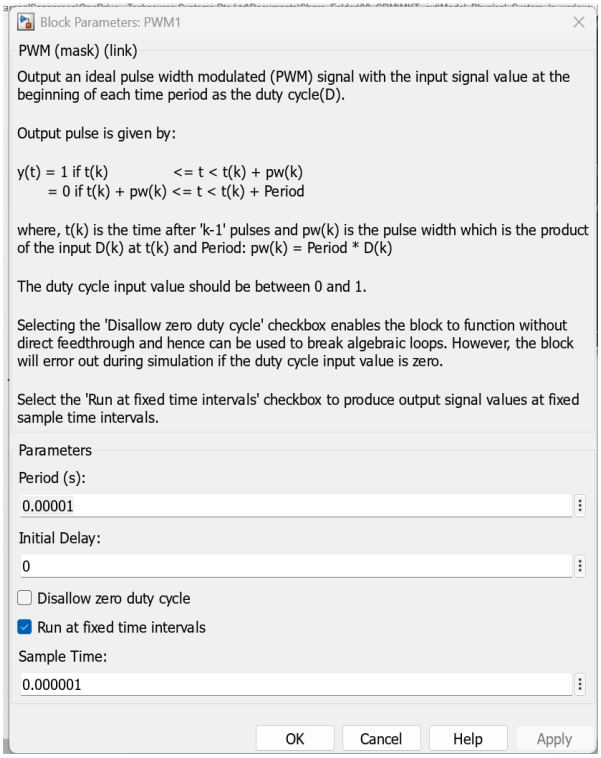



2. Connect Buck converter circuit

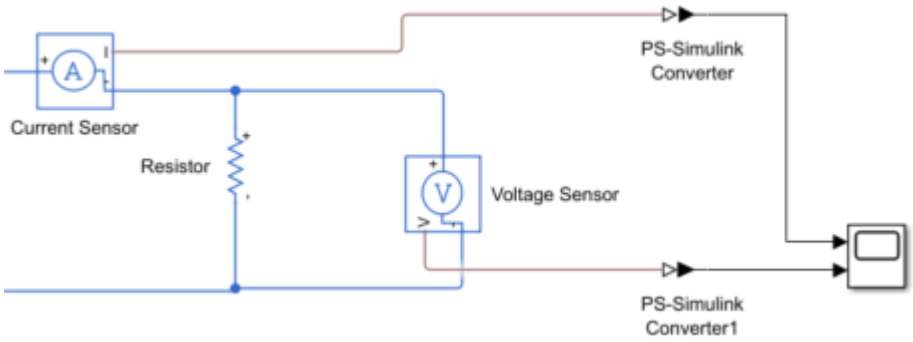



3. Adding "PWM" to input "Switch" Block, set up constant at 0.8 for duty cycle, Set Period to 1e-5, Sample time at 1e-6



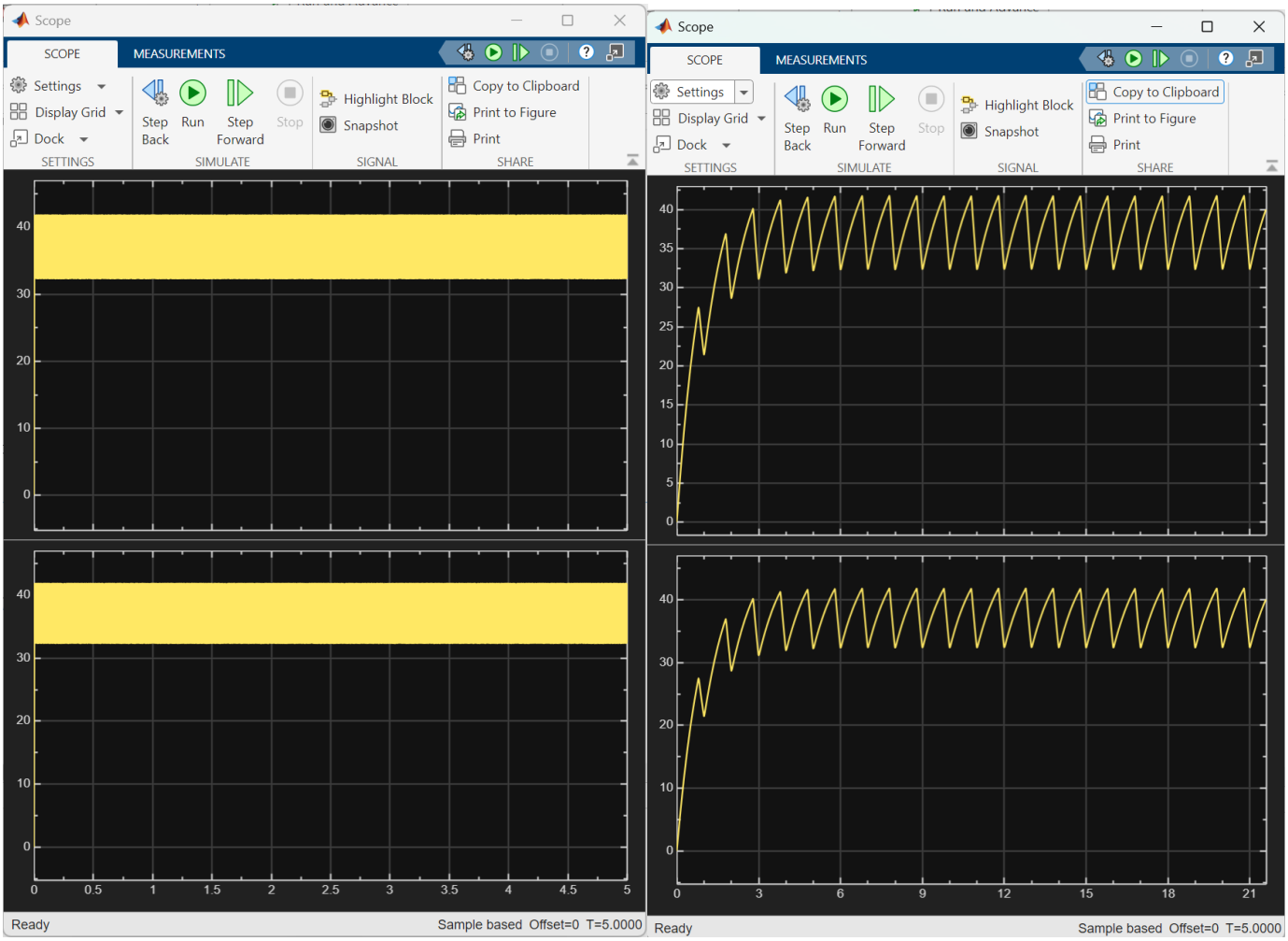



4. Adding "Scope" Block to see the output




5. Change simulation stop time to 5 seconds and click "Run" to start the simulation --> Check the result at "Scope" block

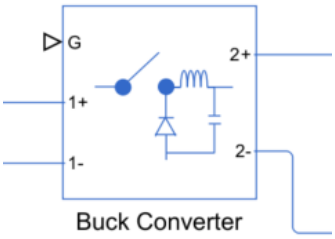
*You may zoom in to scope down the time at 0 - 0.005 to see the transient response



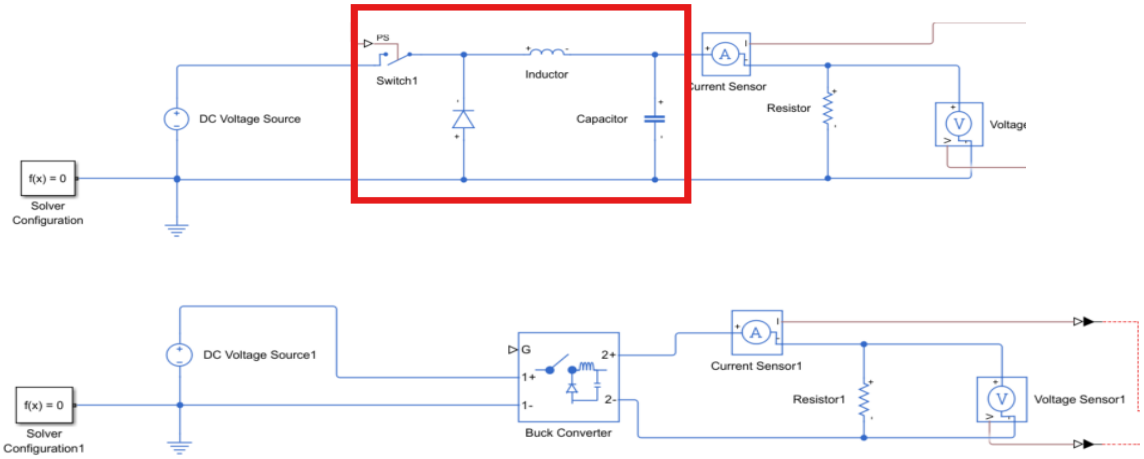
## Task 2: Create built-in Buck converter circuit from Simscape Electrical

1. Drag the block from

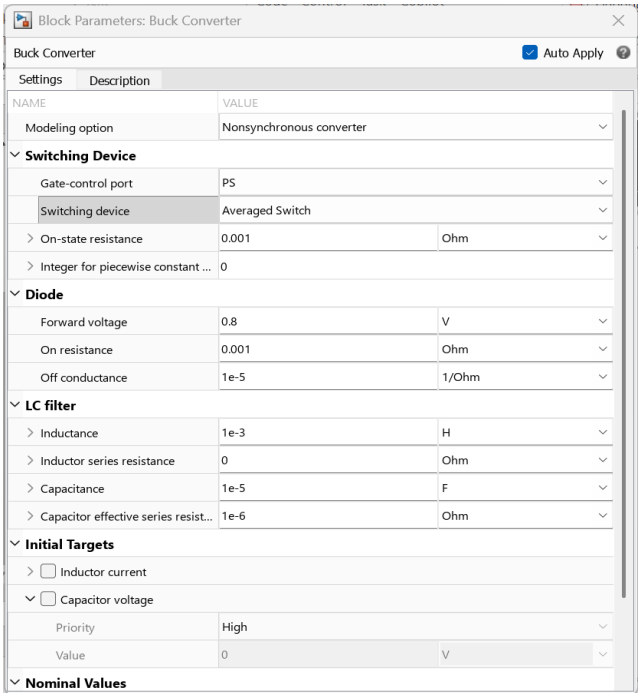
**Simscape>Electrical>Semiconductors & Converters>Buck Converter**




2. Replace the "Buck Converter" block to the previous circuit

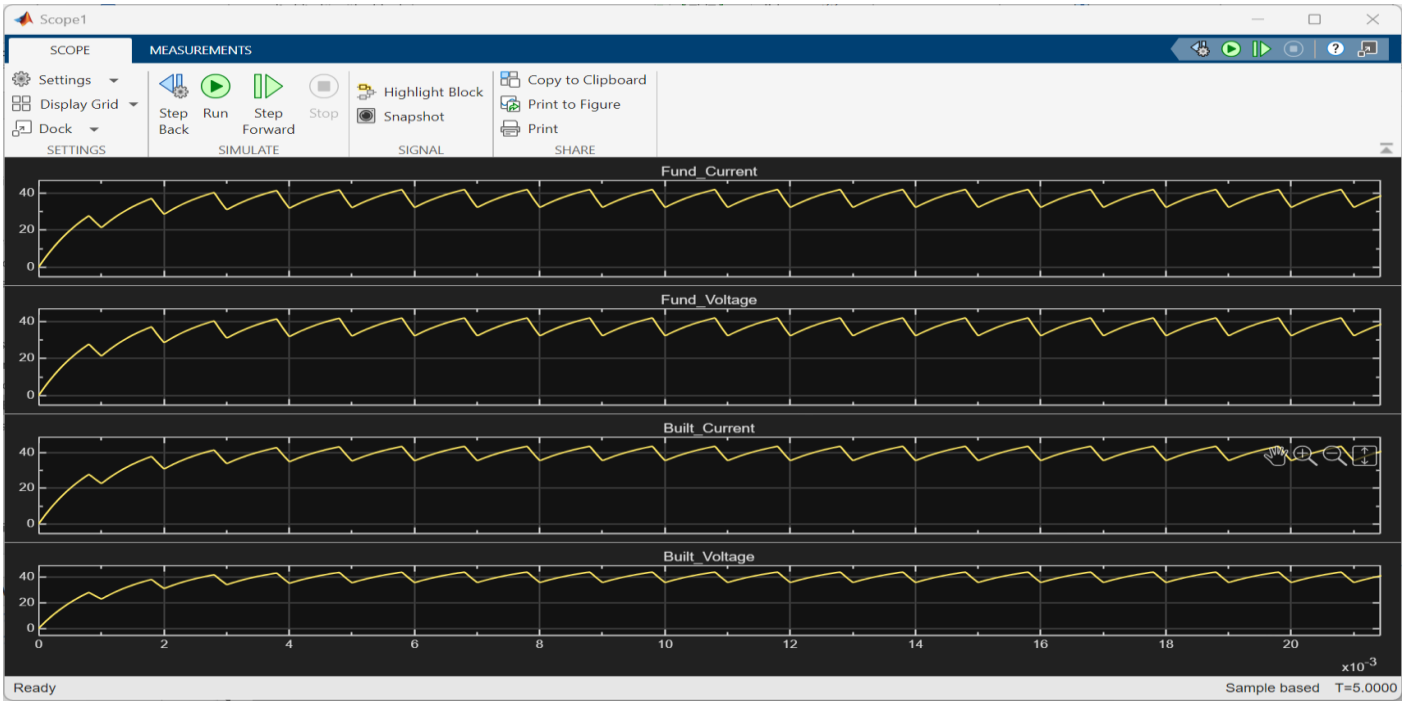


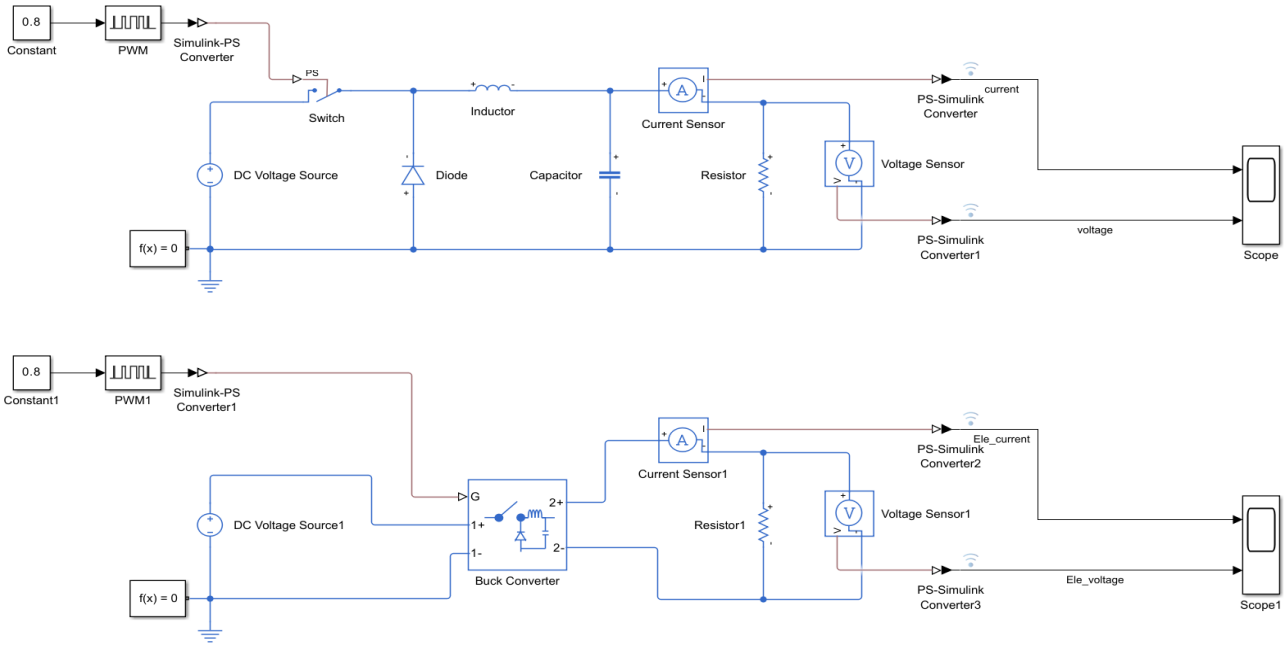

3. Set the parameter as setting in the previous model



4. Change simulation stop time to 5 seconds and click "Run" to start the simulation --> Check the result at "Scope" block

*You may compare the difference between 2 approach models by merging the signal to the same scope

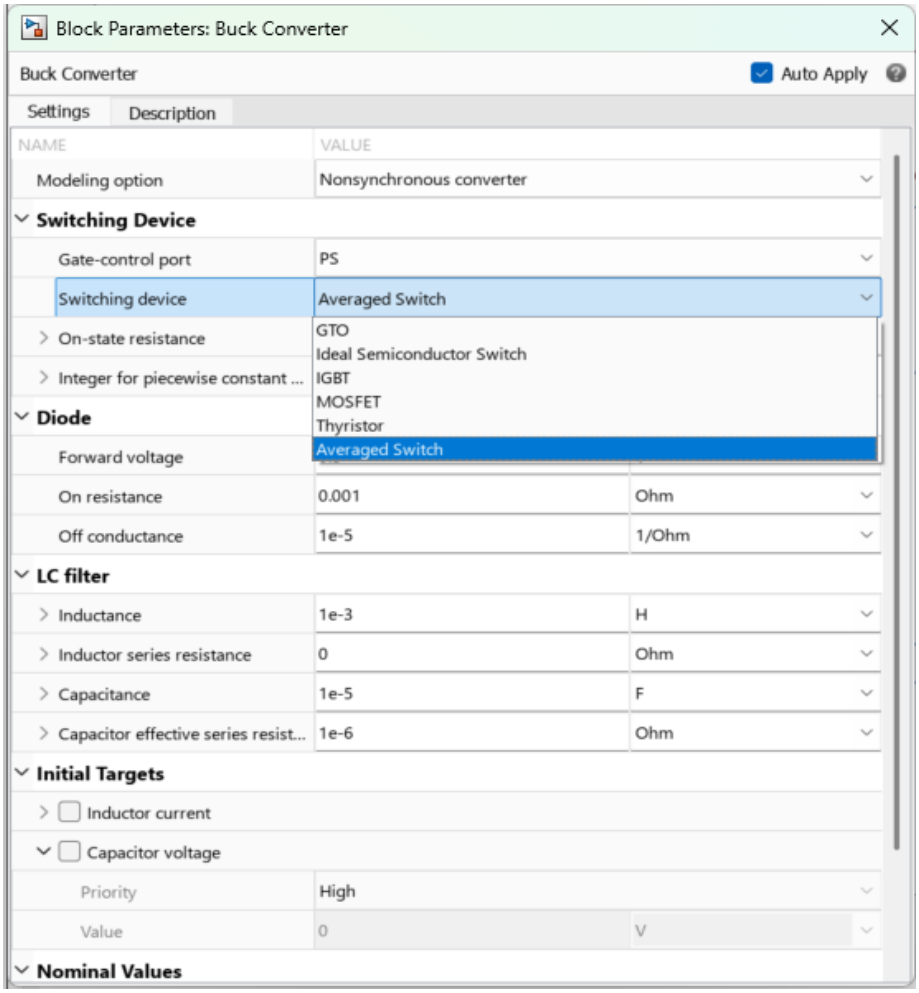


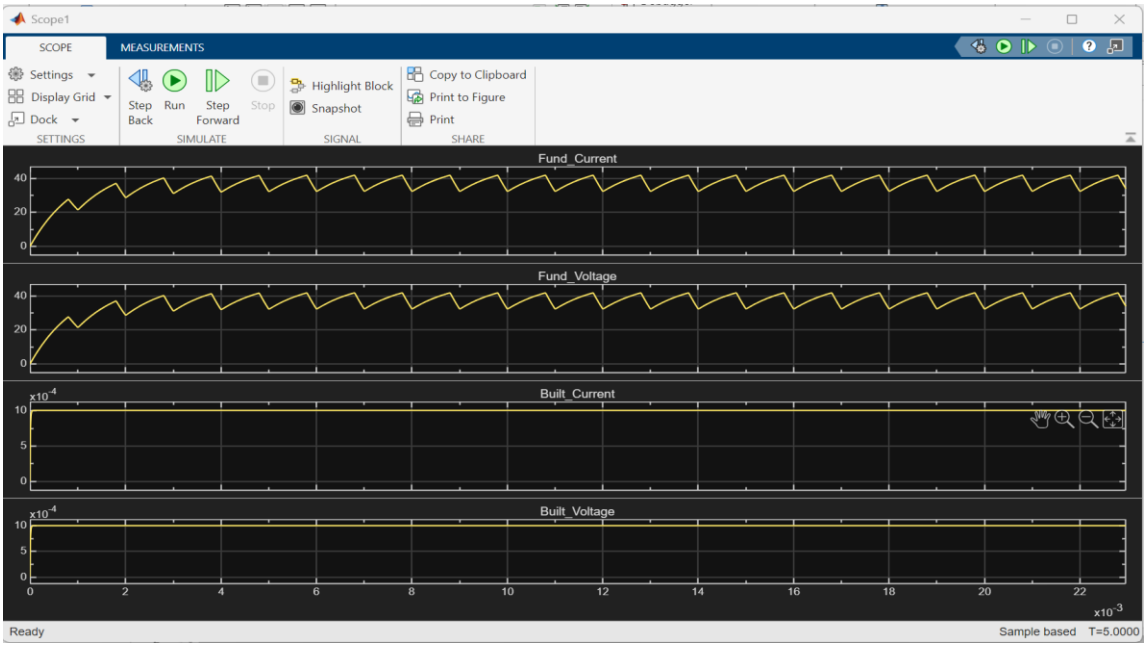

```
open("Buck_Converter_2_approch.slx")
```

## Task 3: Achieve higher fidelity model by configuration parameter

1. Checking "Buck Converter" Block parameter --> Checking "Switching device" --> Change to "Ideal Semiconductor Switch"

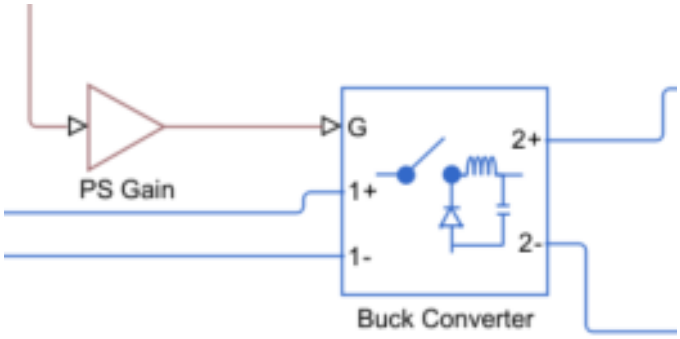



2. Change simulation stop time to 5 seconds and click "Run" to start the simulation --> Check the result at "Scope" block compared to the fundamental circuit

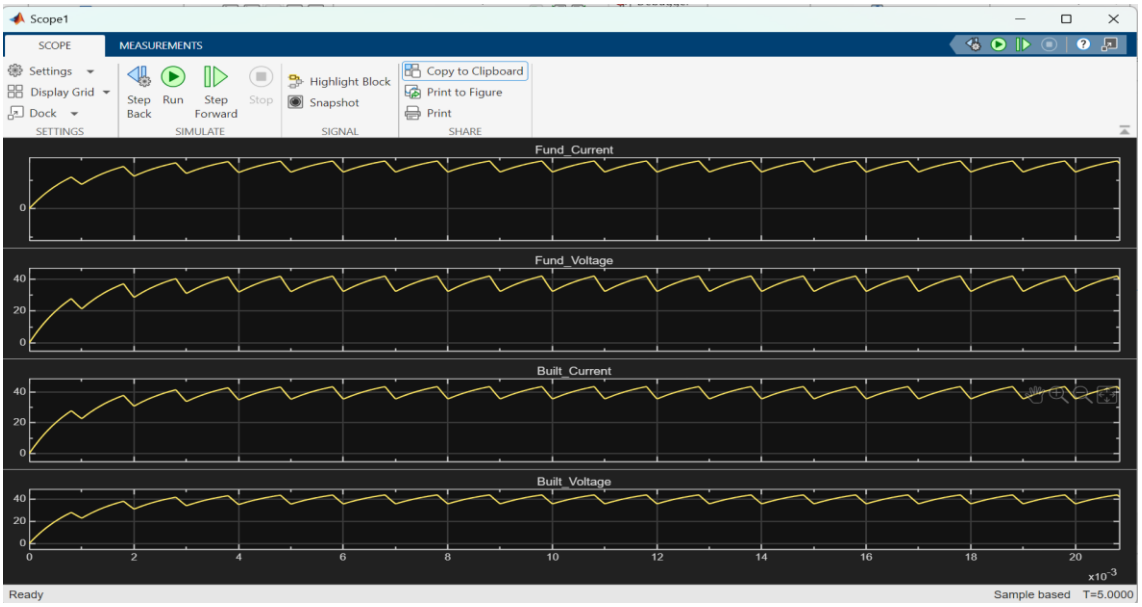


3. Add "PS Gain" from **Simscape>Foundation Library>Physical Signals** between PWM signals to Gate of "Buck Converter" --> Set the gain at 12

*PWM voltage signal needs to be more than threshold to drive the gate open (More fidelity)

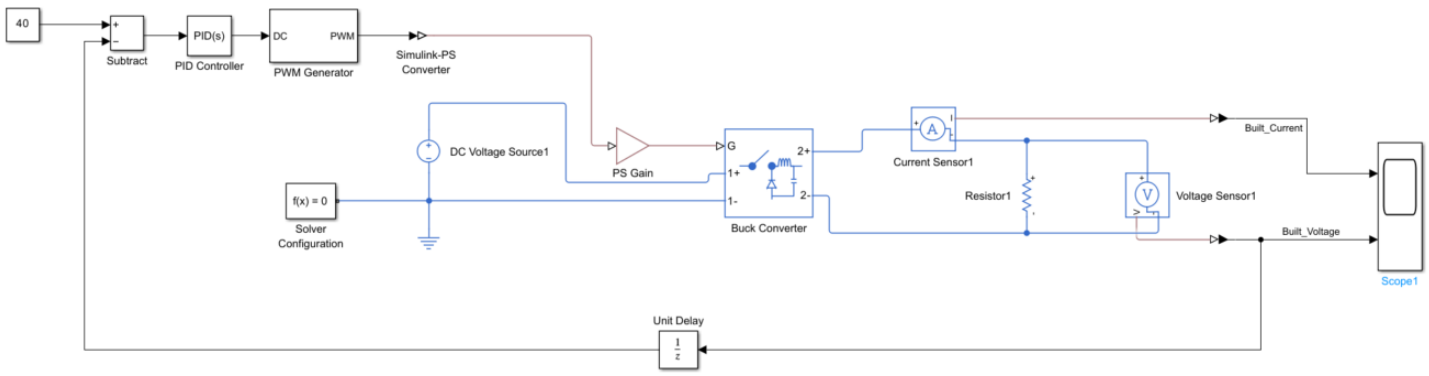


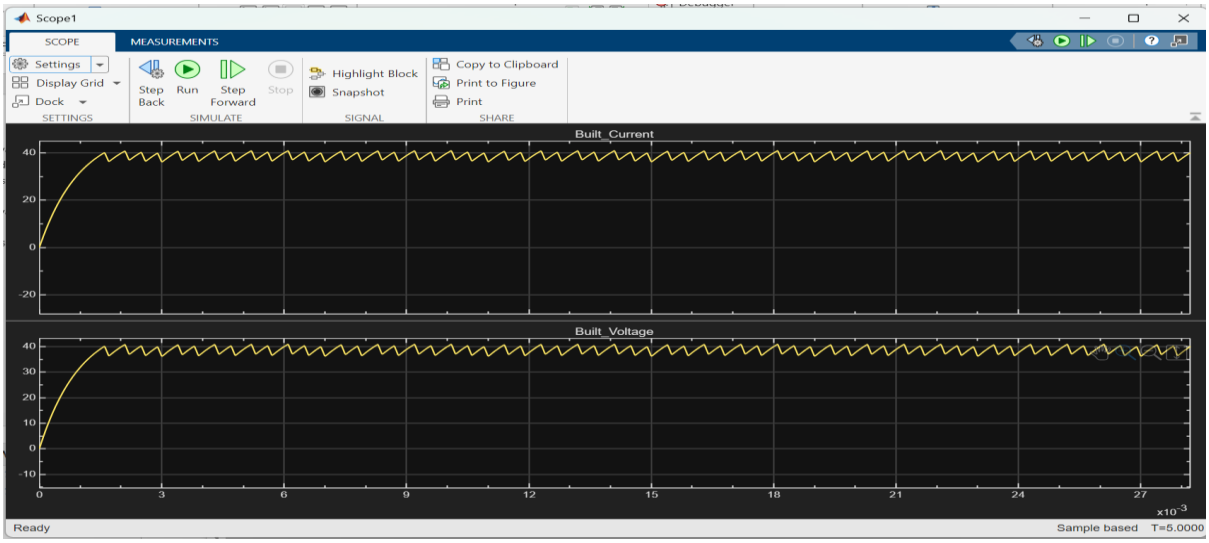

4. Simulation again and checking the scope



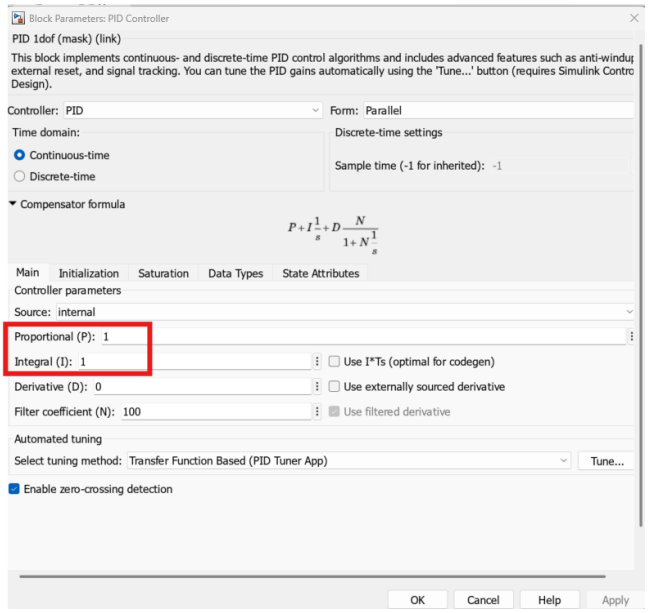

## Task 4: Voltage control with PID controller

1. Adding "Unit Delay" block to feedback the Output volage of Buck converter
2. Adding "Subtract" block --> Subtract "Feedback voltage" with constant (Set as 40 for the default setpoint) to get the error value
3. Adding "PID controller" to make the PID control --> Sending the PWM control to PWM Generator



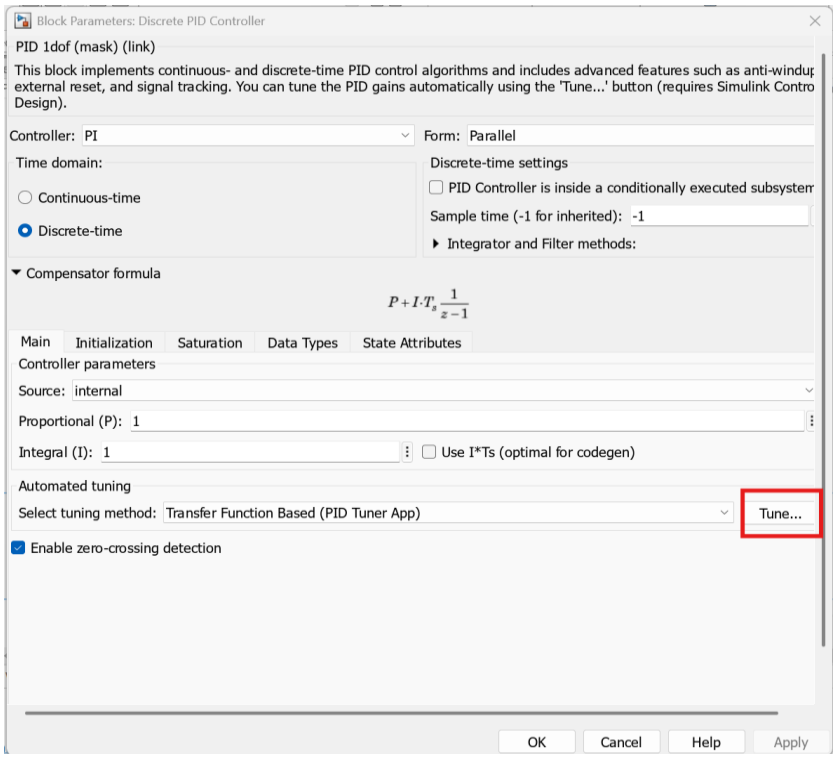



*You may try to change the value of PID gain by double clicking at "PID controller"



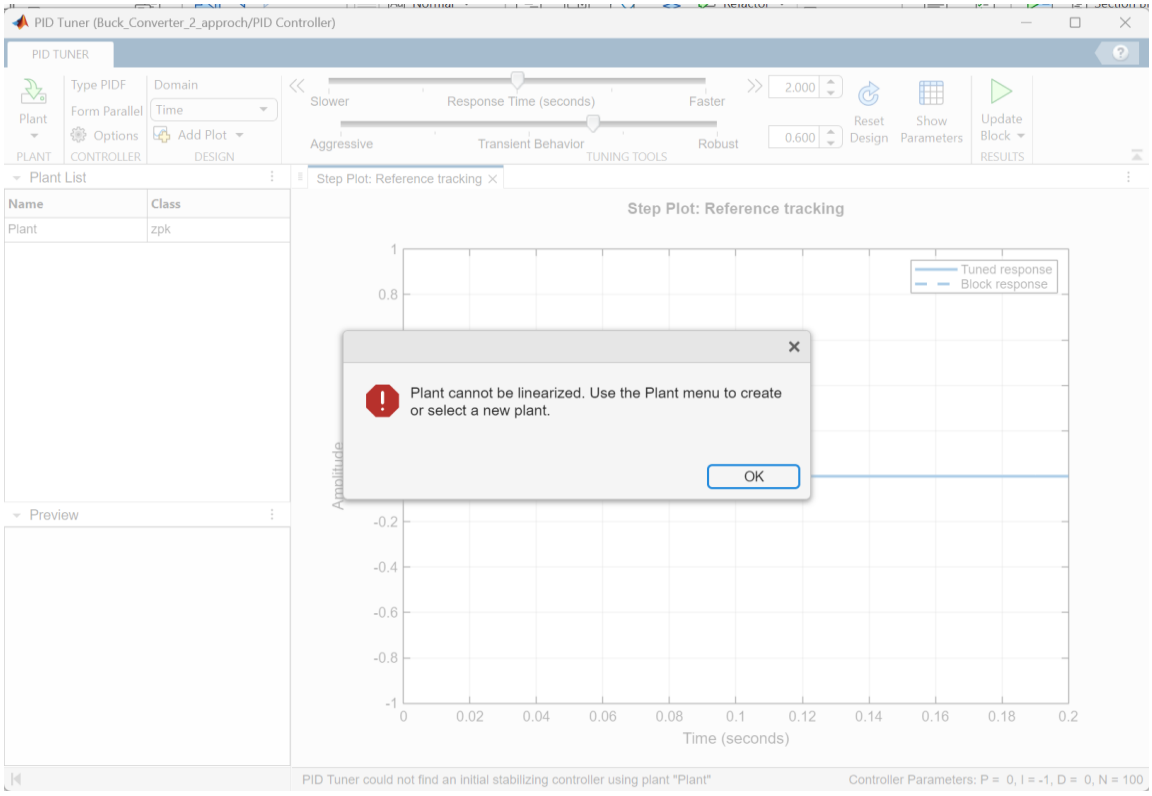

## Task 5: Tunning Controller with PID tunner

- Double click at "**Discrete PID Controller**" --> Click "**Tune**" button

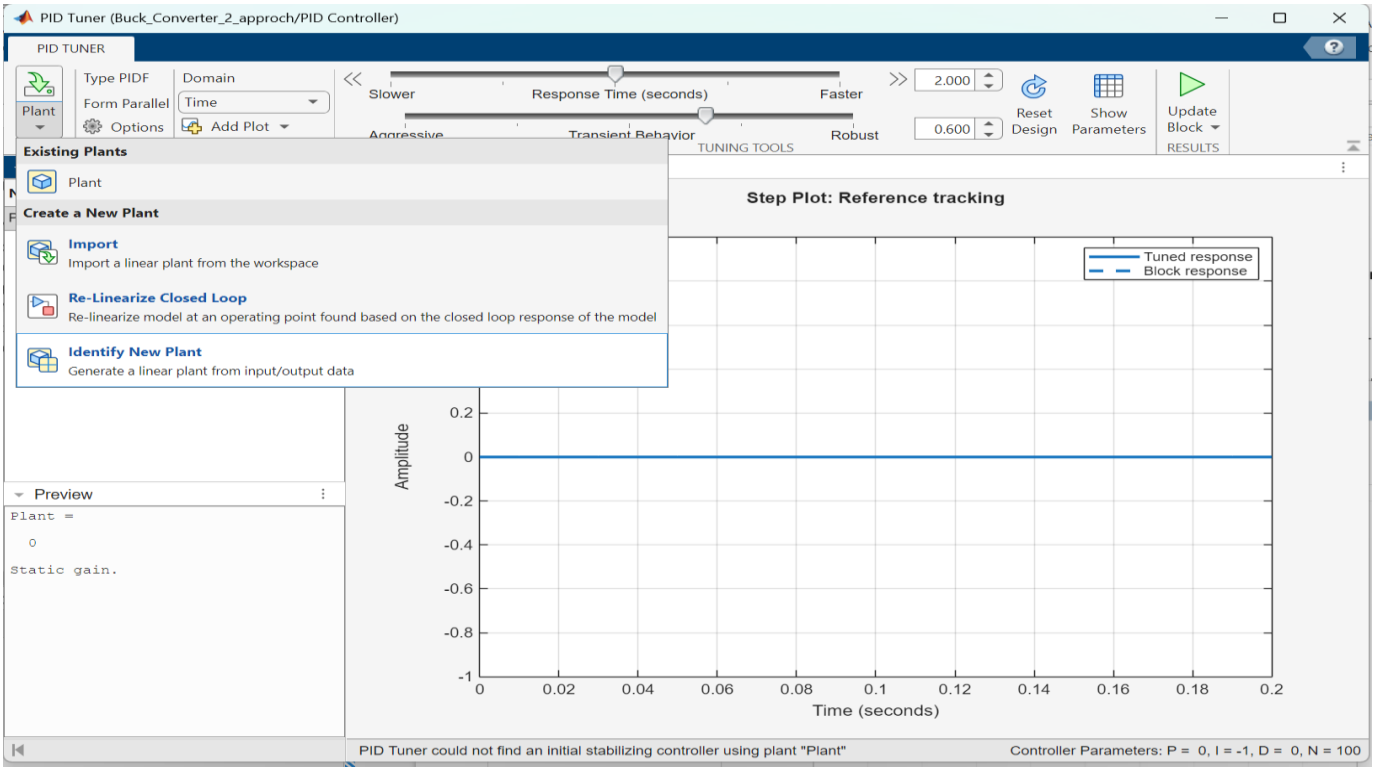



- PID tuner window will pop up. You can try to tune your controller's "**Response time**" and "**Transient Behavior**" by sliding the bar in picture below --> Click "**Update Block**" after you finish

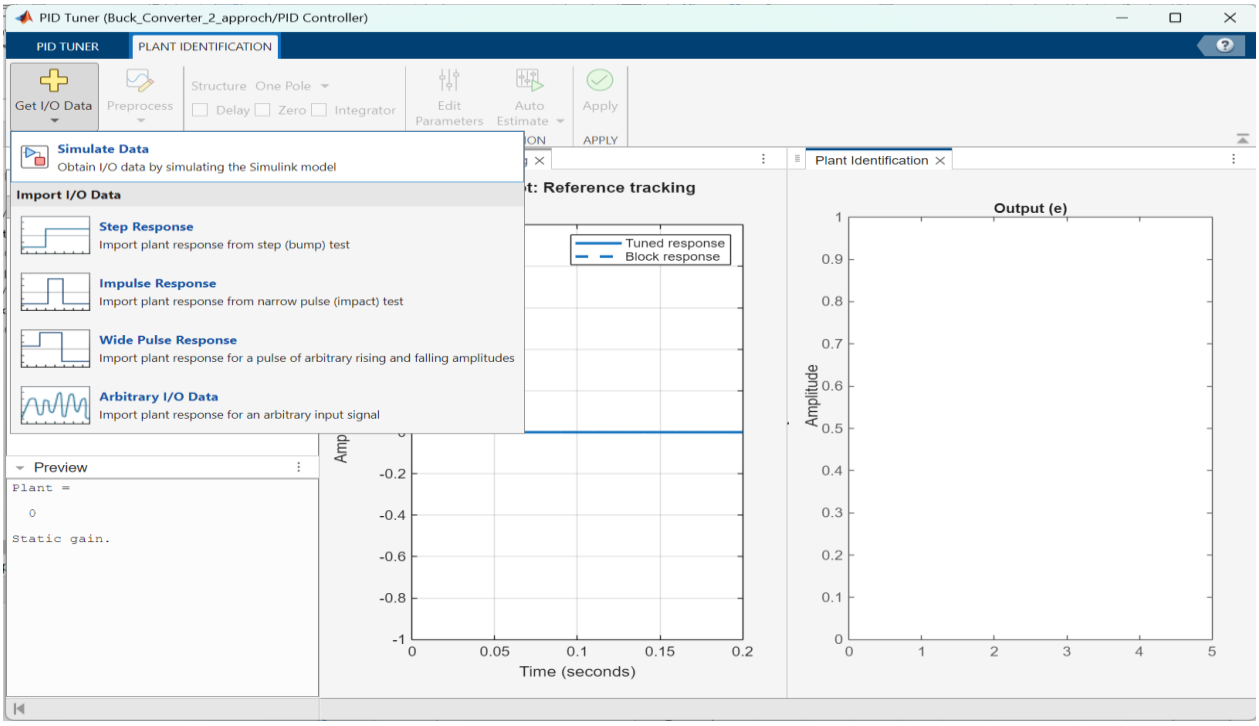
*In this case you may face that "Plant cannot be linearized. Use the Plant menu to create or select a new plant." --> Because the system cannot be linearized --> Linearize manually by selecting the operating point.



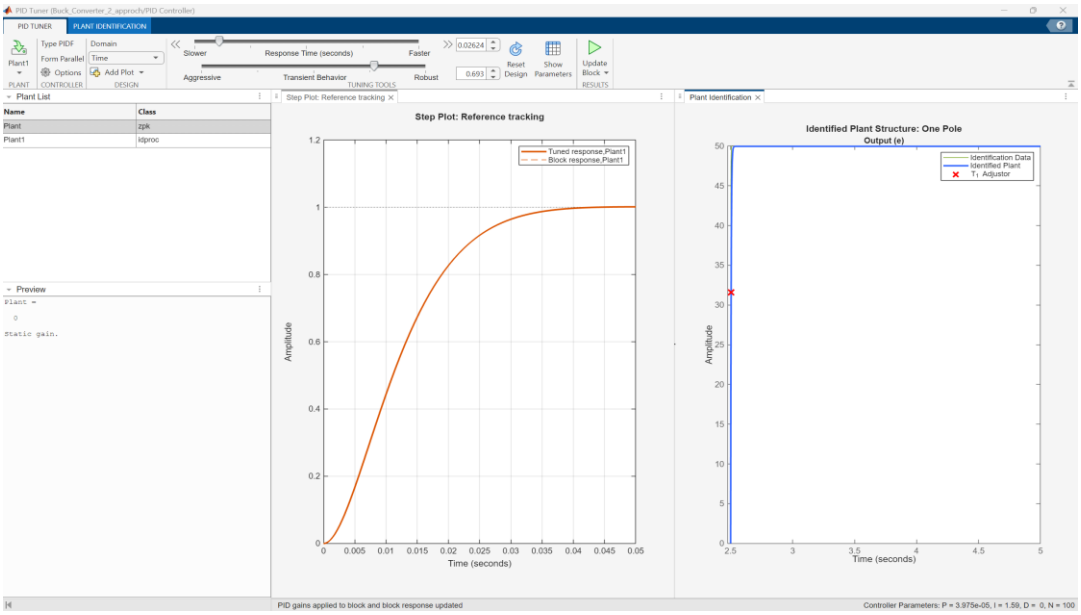
- Goto "Identify New Plant"



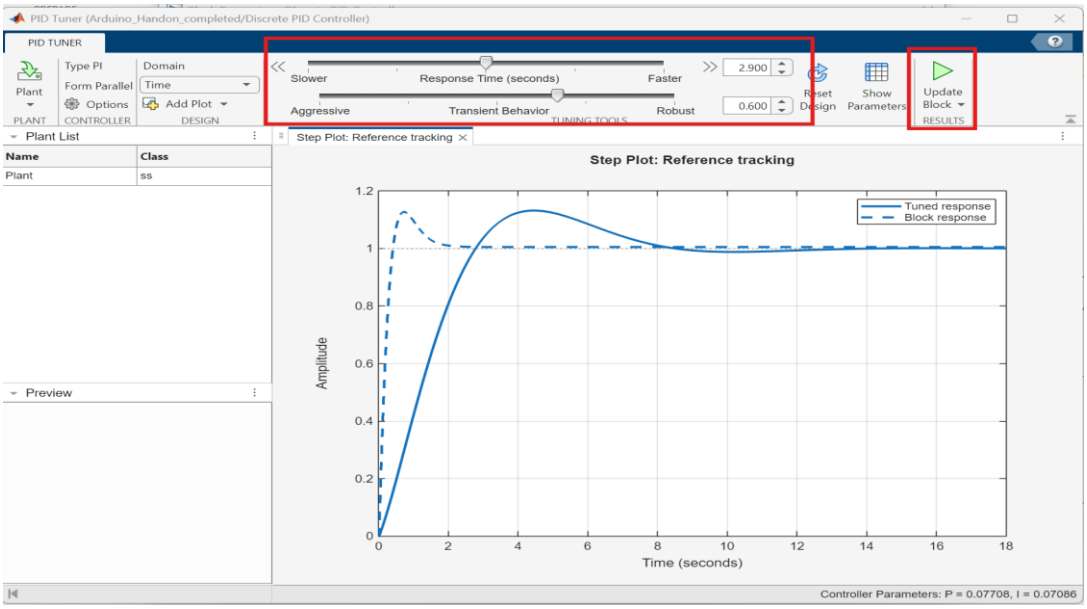

- Go to "PLANT IDENTIFICATION" --> "Get I/O Data" --> Simulate Data



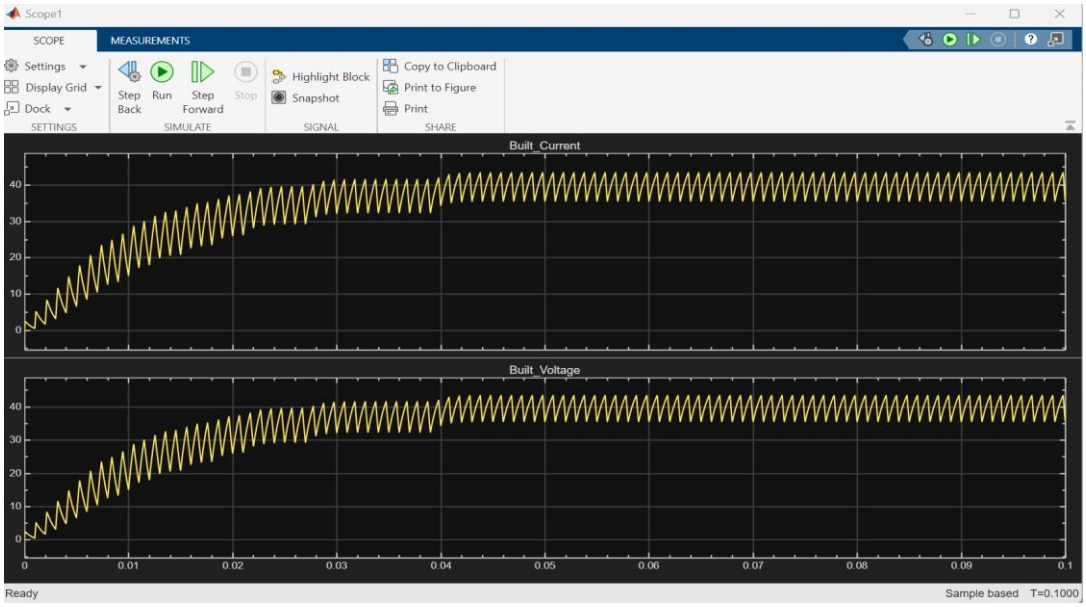
- Identify the model and click "Accept" it




- Slide the bar to tune the response of the new plant



- Try to "**Run**" simulation again to see the change after your tunning




```
open("Buck_Converter_2_PID_Tune.slx")
```