

# Self Project

## Output Voltage Regulation of Buck Converter using Type-2 Compensator

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July, 2025

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### ► Objective:

The objective of this experiment is to design a Type-2 compensator for a buck converter to regulate its output voltage.

### ► Parameters:

| Parameter  | Value             |
|--|-------------------|
| Input Voltage  | 24                |
| Inductor   | $50\mu\text{H}$   |
| Capacitor  | $100\mu\text{F}$  |
| Load resistance  | $2\Omega$         |
| Switching frequency                                    | 100kHz            |
| Desired gain crossover frequency of compensated system | 90 to 120 degrees |

### ► Compensator Design (K factor Method):

For type-2 compensator we have the Transfer function given by

$$G_{C2} = G_{MB} \frac{\left(1 + \frac{\omega_z}{s}\right)}{\left(1 + \frac{s}{\omega_p}\right)} \cdot s \quad (1)$$

where

$$G_{MB} = \frac{1}{\text{Plant gain at } \omega_c} \quad ; \quad \text{Absolute gain}$$

$$\omega_z = \frac{\omega_c}{k}, \quad \omega_p = k\omega_c$$

$$k = \tan\left(45^\circ + \frac{\text{boost}}{2}\right)$$

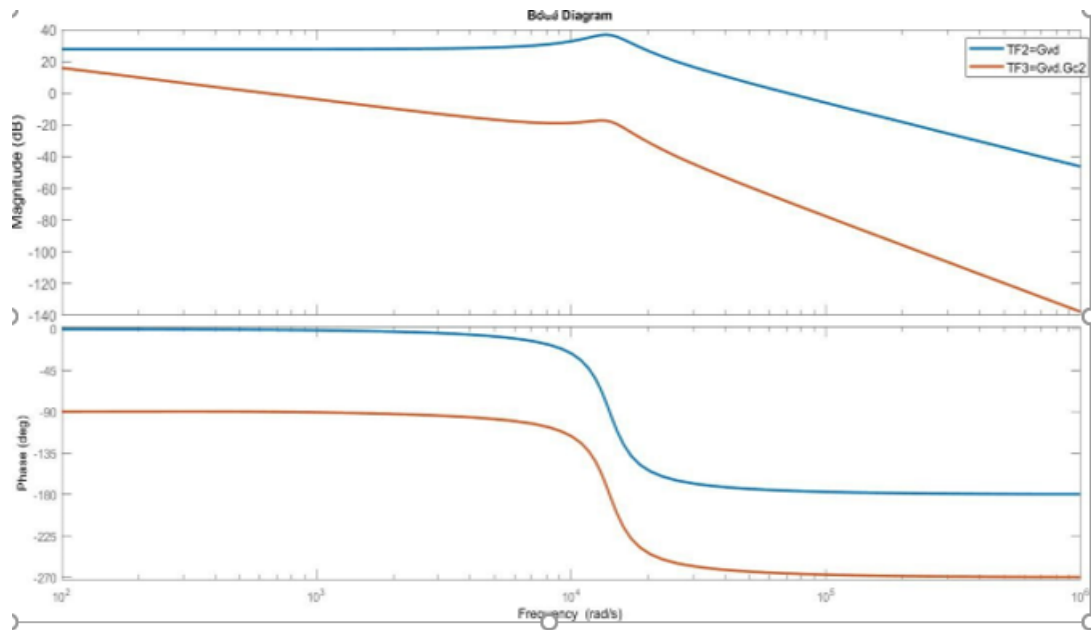
$$G_{vd} = \frac{-V_{in}}{s^2 LC + \frac{sL}{R} + 1}$$

After substituting the values we got the following Transfer function

$$G_{C2} = \frac{26.54s + 16401}{s^2 + 638s}$$

$$G_{vd} = \frac{24}{5 \times 10^{-9}s^2 + 25e^{-6}s + 1}$$

► Bode Plot:



► Stability Margins:

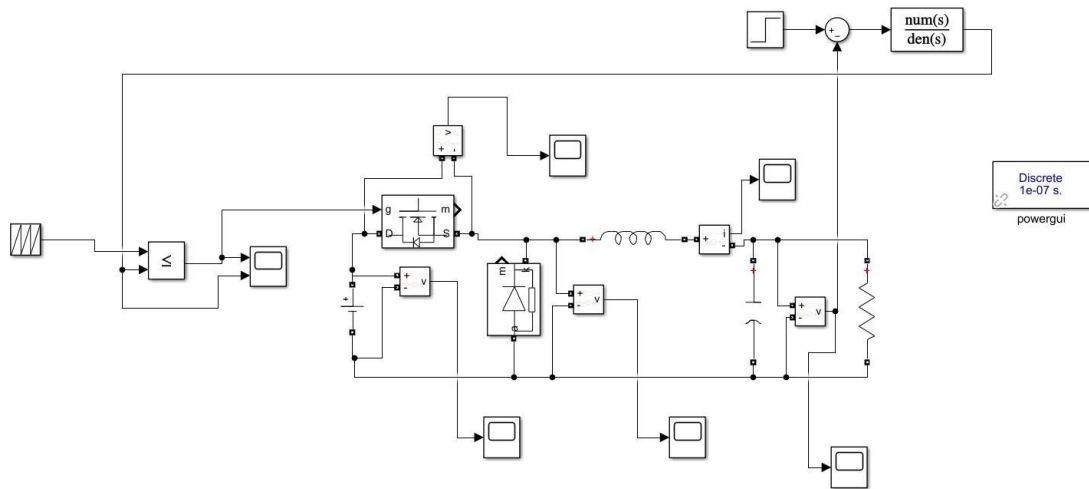
a)  $G_{vd}$

Gain Margin: Inf    GM Frequency: Inf  
 Phase Margin: 4.2185    PM Frequency:  $7.0620 \times 10^4$   
 Delay Margin:  $1.0426 \times 10^{-6}$     DM Frequency:  $7.0620 \times 10^4$   
 Poles:  
 $P_1 = 1.0 \times 10^4 (-0.2500 + j1.3919)$   
 $P_2 = 1.0 \times 10^4 (-0.2500 - j1.3919)$

b)  $G_{C2}$

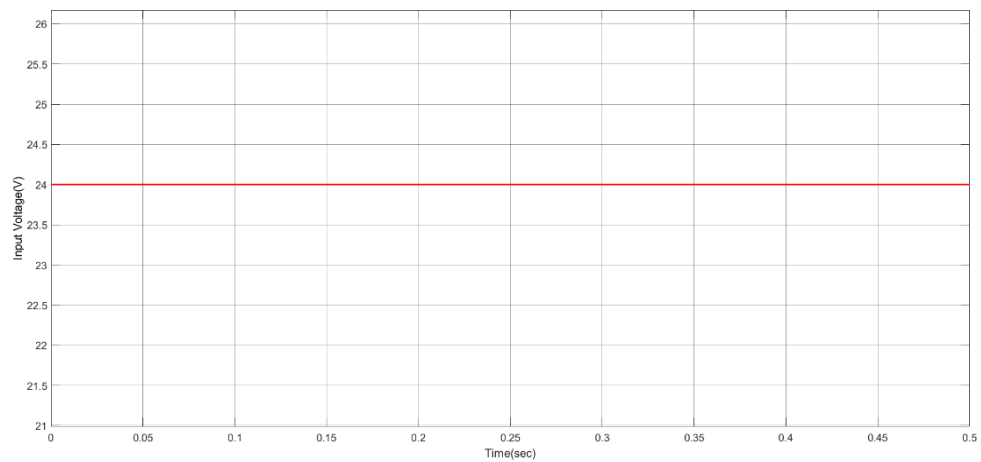
Gain Margin: 7.8542    GM Frequency:  $1.4146 \times 10^4$   
 Phase Margin: 90.0123    PM Frequency: 628.0470  
 Delay Margin: 0.0025    DM Frequency: 628.0470  
 Poles:  
 $P_1 = 0.0000 + 0.0000j$   
 $P_2 = -0.2500 + 1.3919j$   
 $P_3 = -0.2500 - 1.3919j$   
 $P_4 = -0.0638 + 0.0000j$

► MATLAB/SIMULINK SIMULATION:

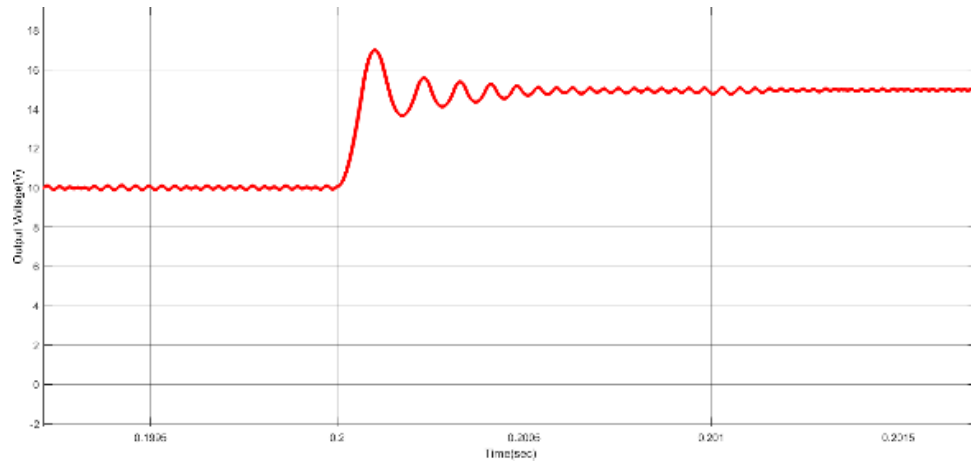


► SIMULATED WAVEFORMS:

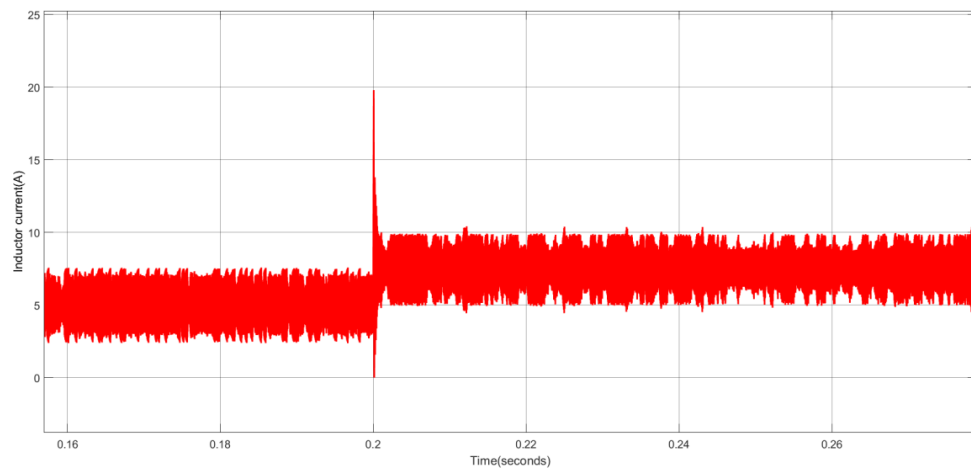
(a) input Voltage Waveform



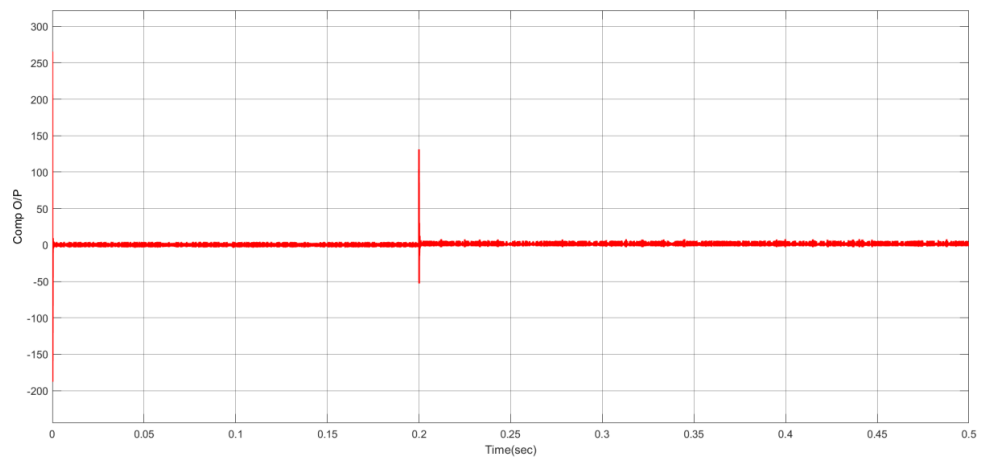
(b) Output Voltage Waveform



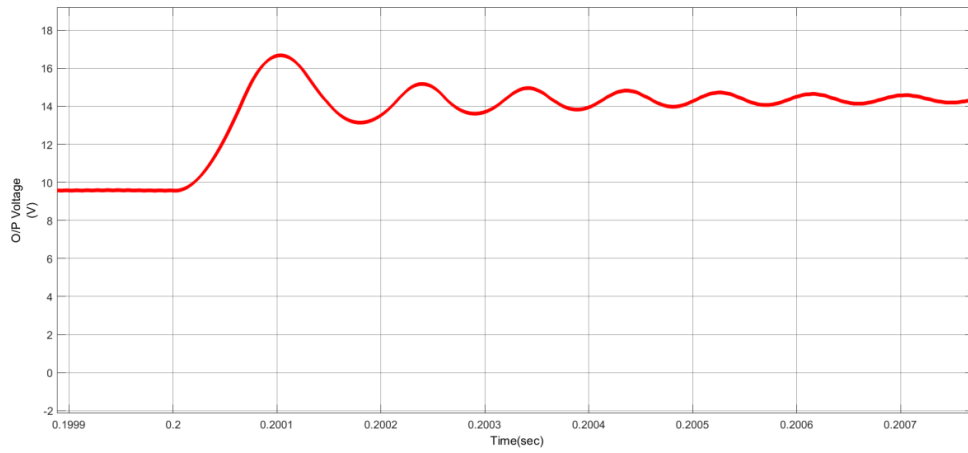
(c) Inductor Current Waveform



(d) Output Voltage with Compensator



(e) Output Voltage without Compensator



## (f) Simulation configuration parameters

Search

**Solver**

- Data Import/Export
- Math and Data Types
- Diagnosics
- Hardware Implementation
- Model Referencing
- Simulation Target
- Code Generation
- Coverage
- Simscape
- Simscape Multibody

Simulation time

Start time: 0.0 Stop time: 0.5

Solver selection

Type: Fixed-step Solver: ode4 (Runge-Kutta)

▼ Solver details

Fixed-step size (fundamental sample time): 1e-7

Tasking and sample time options

Periodic sample time constraint: Unconstrained

- ☐ Treat each discrete rate as a separate task
- ☐ Allow tasks to execute concurrently on target
- ☐ Automatically handle rate transition for data transfer
- ☐ Higher priority value indicates higher task priority

OK Cancel Help Apply

## ► Eagle Schematic:



has also been reduced by using the compensator.

Furthermore, the PCB design of the whole system was implemented with the help of **Eagle Software**.