Self Project

Output Voltage Regulation of Buck Converter using Type-2 Compensator

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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	50μH
Capacitor	100μF
Load resistance	2Ω
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

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

where

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

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

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

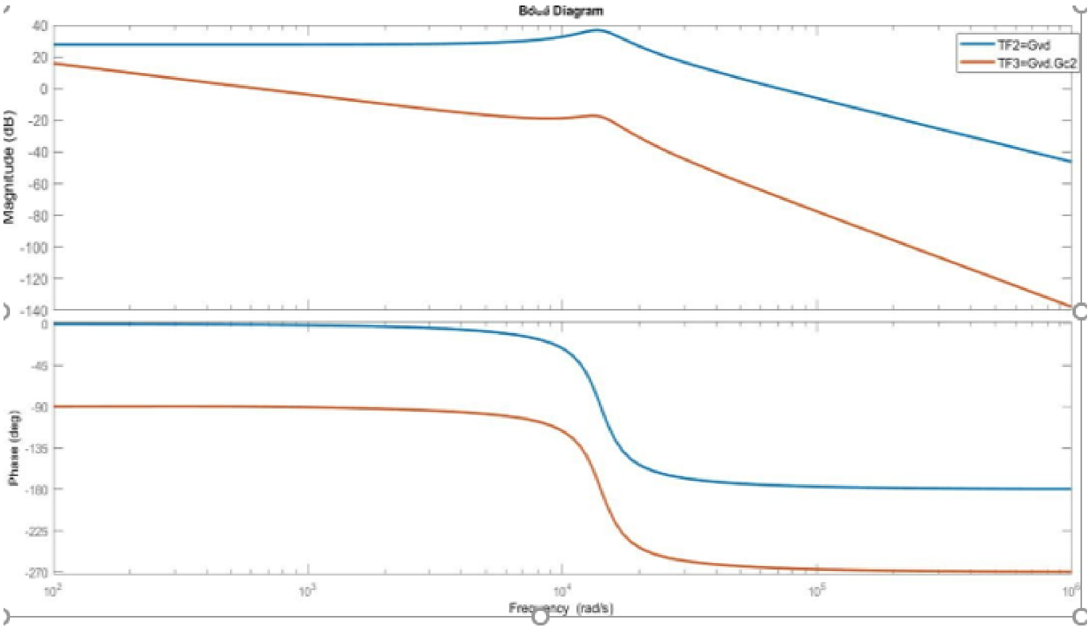
$$G_{vd} = \frac{-V_{in}}{s^2 LC + \frac{sL}{R} + 1}$$

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:**

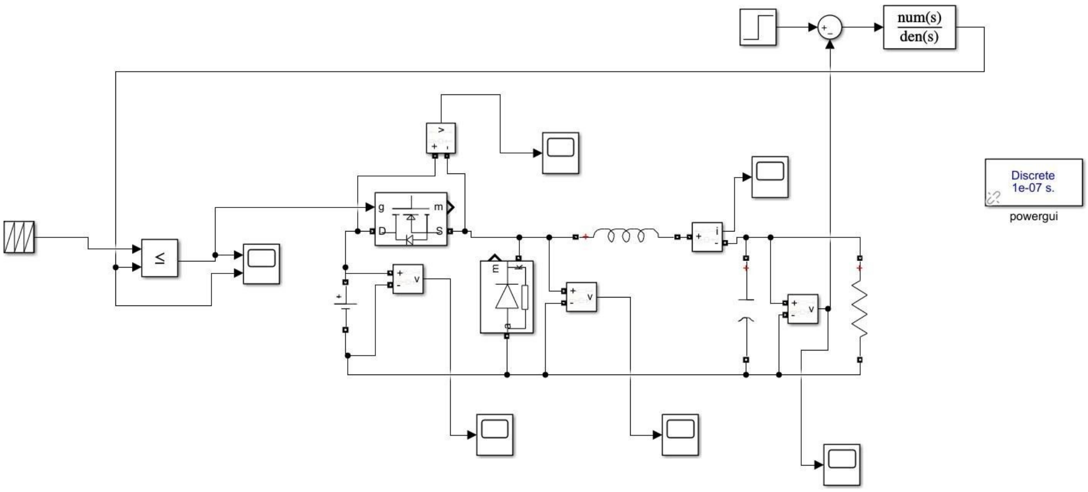
a) G_{vd}

Gain Margin: Inf GM Frequency: Inf
Phase Margin: 4.2185 PM Frequency: 7.0620×10^4
Delay Margin: 1.0426×10^{-6} DM Frequency: 7.0620×10^4
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}

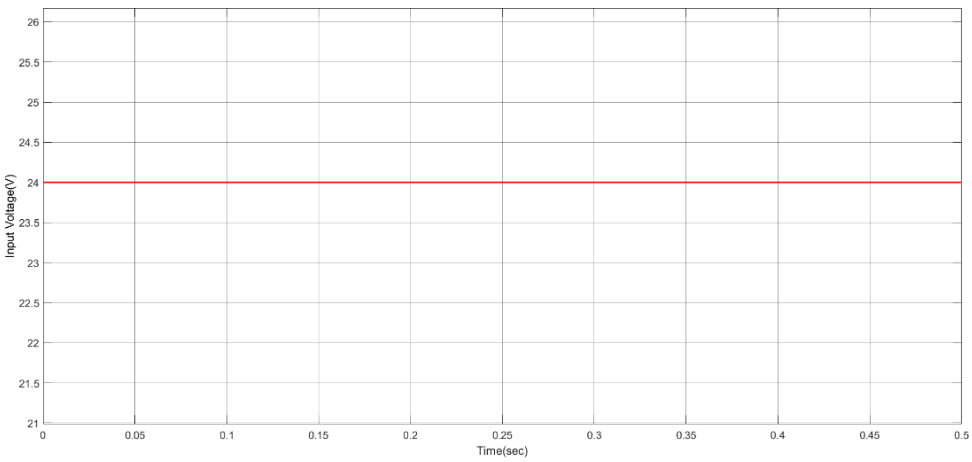
Gain Margin: 7.8542 GM Frequency: 1.4146×10^4
Phase Margin: 90.0123 PM Frequency: 628.0470
Delay Margin: 0.0025 DM Frequency: 628.0470
Poles: $P_1 = 0.0000 + 0.0000j$
$P_2 = -0.2500 + 1.3919j$
$P_3 = -0.2500 - 1.3919j$
$P_4 = -0.0638 + 0.0000j$

▶ **MATLAB/SIMULINK SIMULATION:**

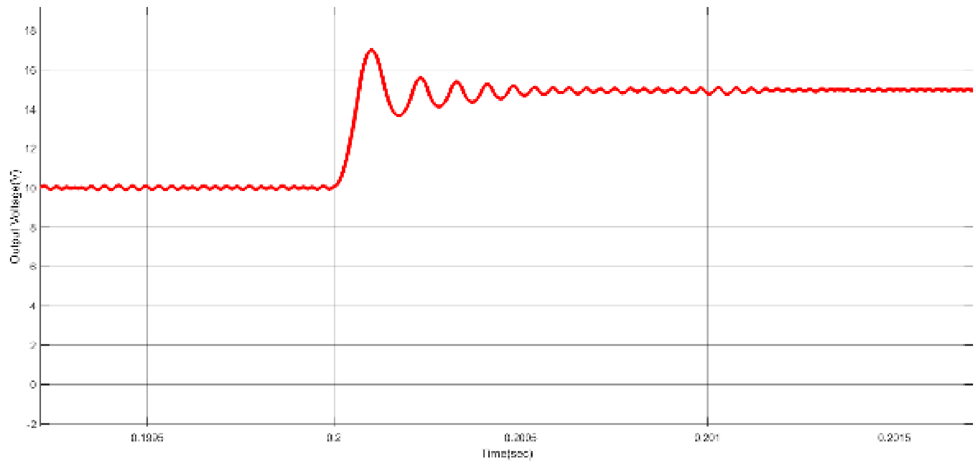


▶ **SIMULATED WAVEFORMS:**

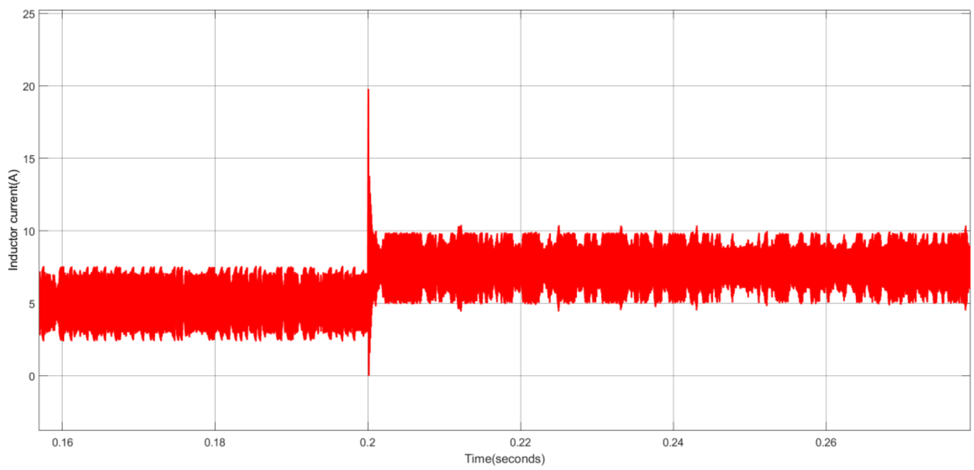
(a) input Voltage Waveform



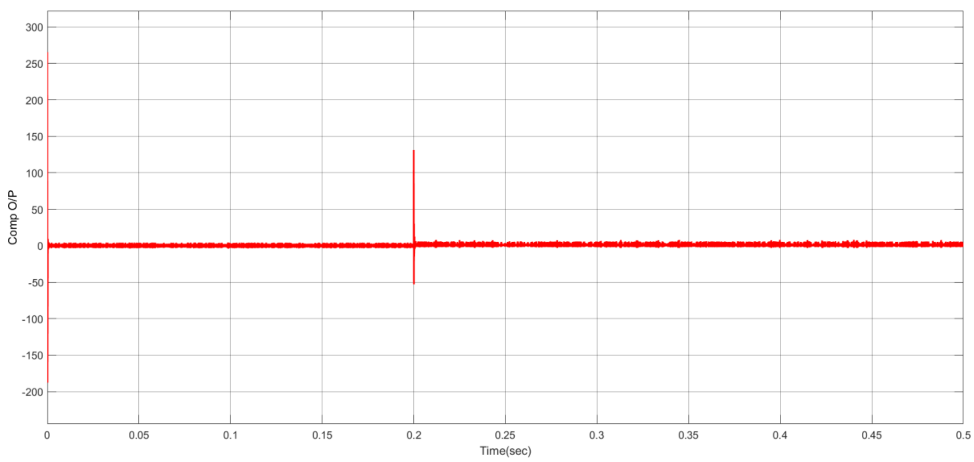
(b) Output Voltage Waveform



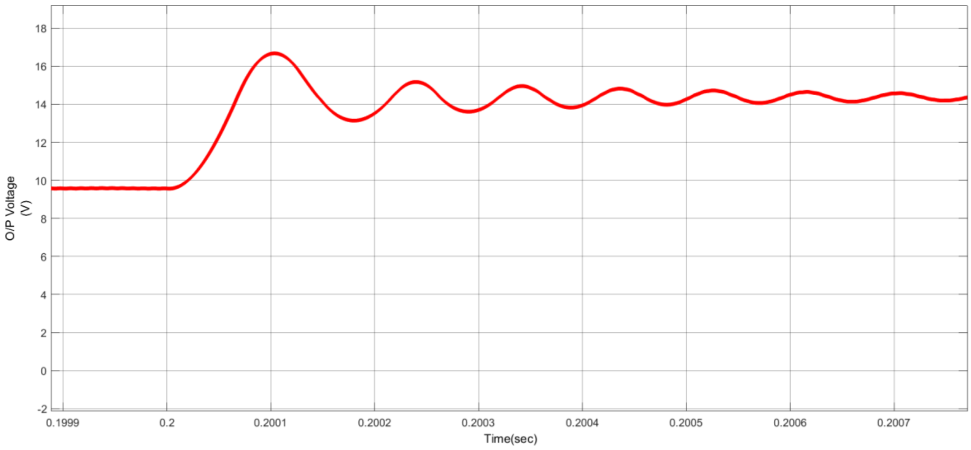
(c) **Inductor Current Waveform**



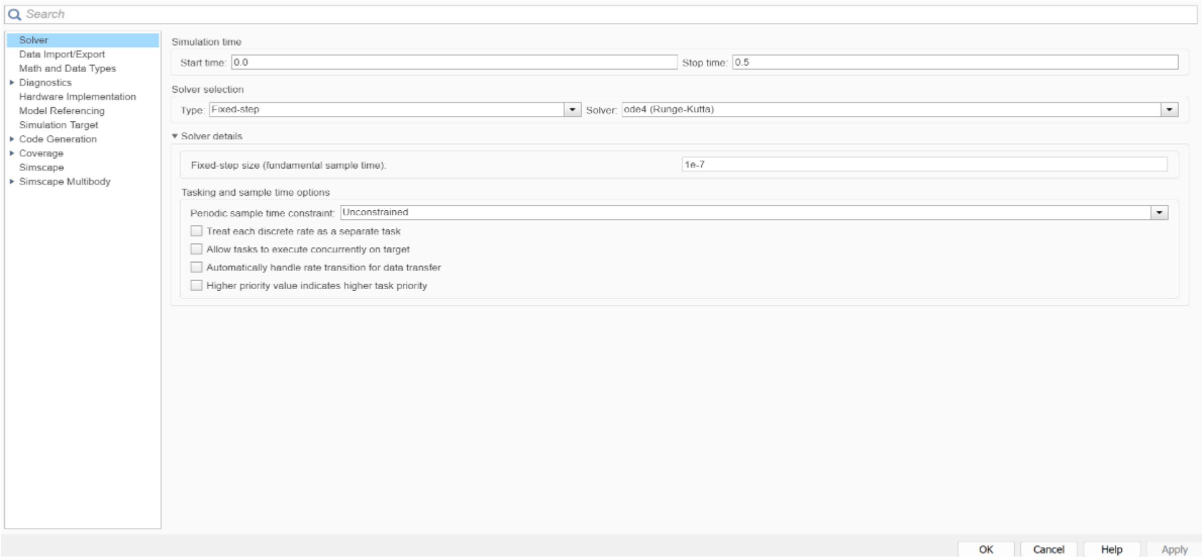
(d) **Output Voltage with Compensator**



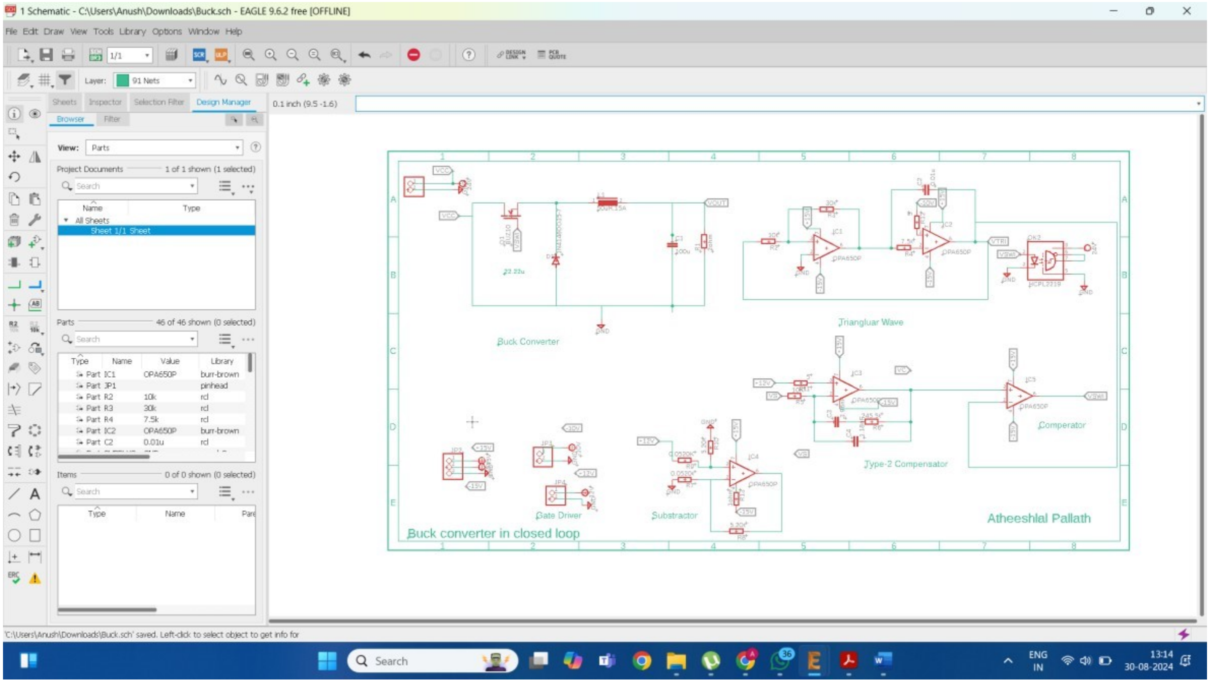
(e) **Output Voltage without Compensator**



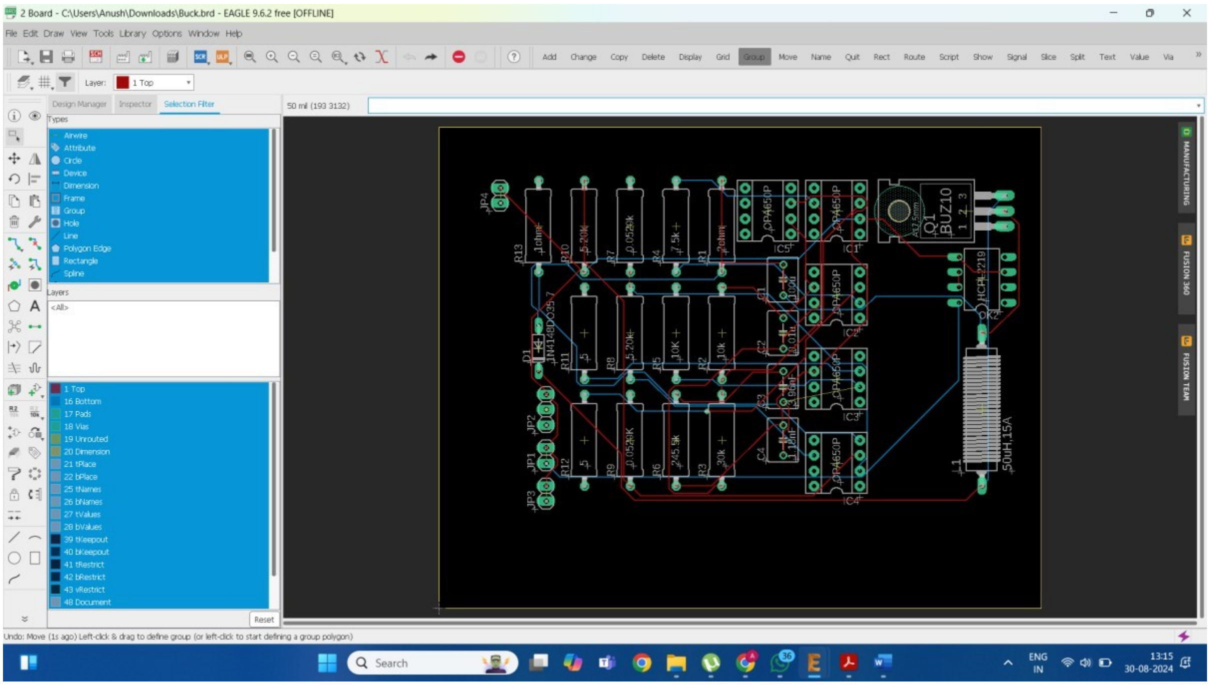
(f) Simulation configuration parameters



▶ Eagle Schematic:



▶ **PCB Design:**



▶ **Conclusion:**

In this experiment, we designed a Type-2 compensator for regulating the output voltage of a buck converter. We used the compensator to improve the transient response along with enhancing the stability margins. It can be observed that the peak overshoot has also been reduced by using the compensator.

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