# Buck Converter using voltage mode control

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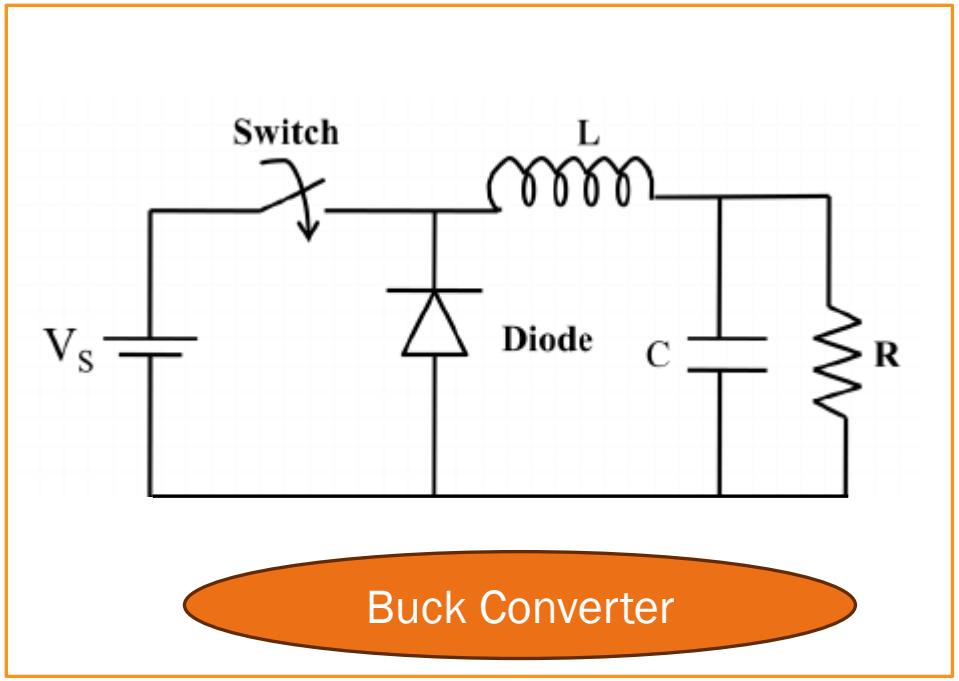
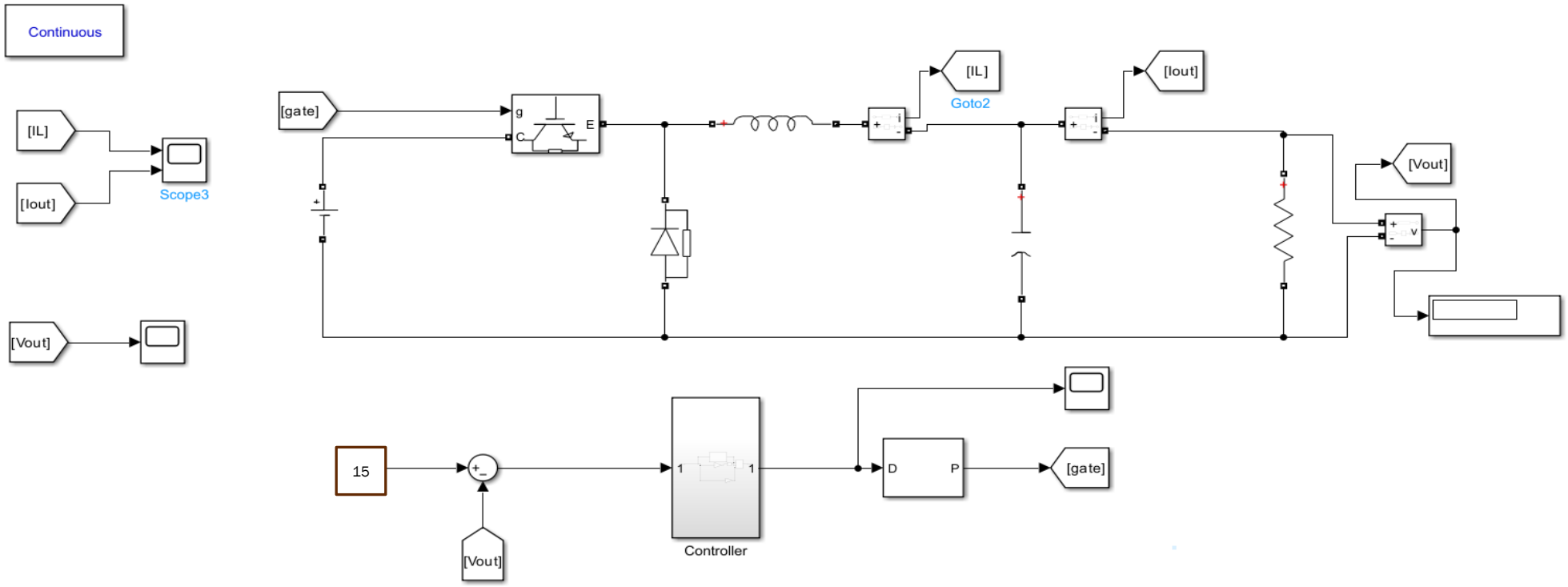
# Parameters of Buck Converter




| Name of parameter | Value of parameter |
|---|---|
| $V_S$ | $30\ V$ |
| $f_{sw}$ | $20\ kHz$ |
| $L$ | $10\ mH$ |
| $C$ | $1000\ \mu F$ |
| $R$ | $100\ \Omega$ |
| $V_o$ | $15\ V$ |

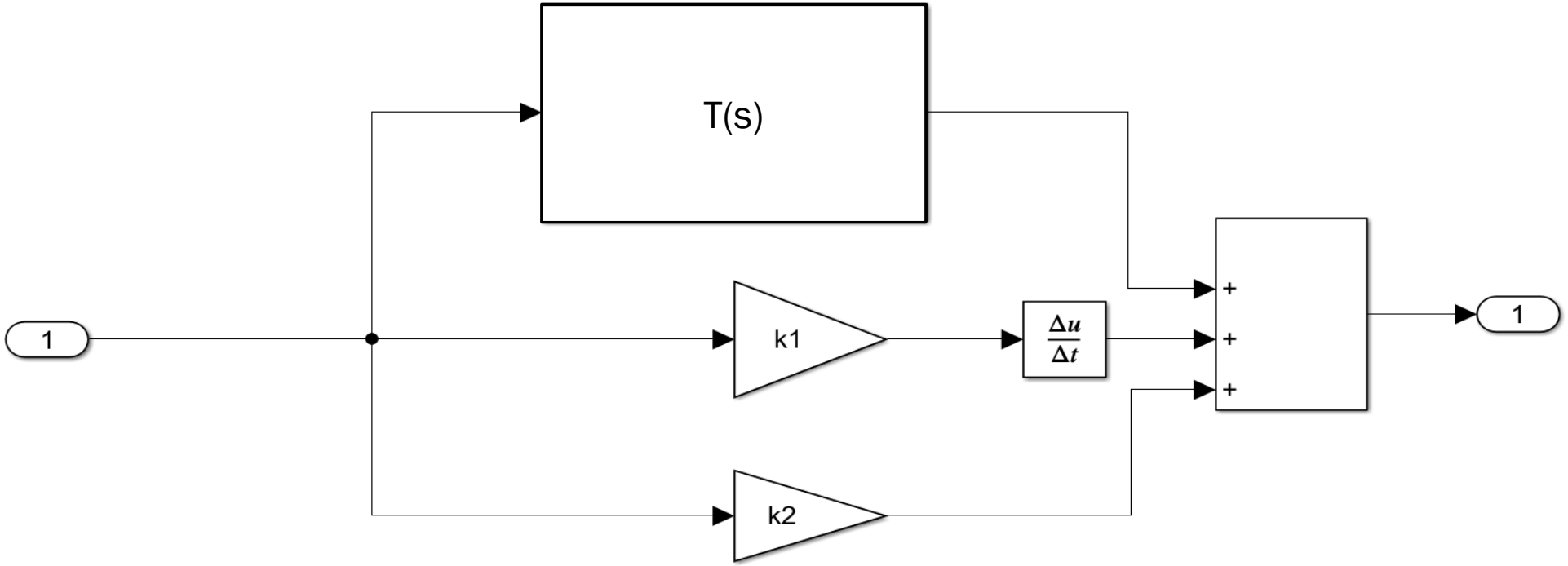
Fang, J. & Tsai, Sheng-Hong & Yan, Jun-Juh & Chen, P. & Guo, Shu-Mei. (2021). Realization of DC-DC Buck Converter Based on Hybrid H2 Model Following Control. IEEE Transactions on Industrial Electronics. PP. 1-1. 10.1109/TIE.2021.3062268.

# Schematic of simulation model



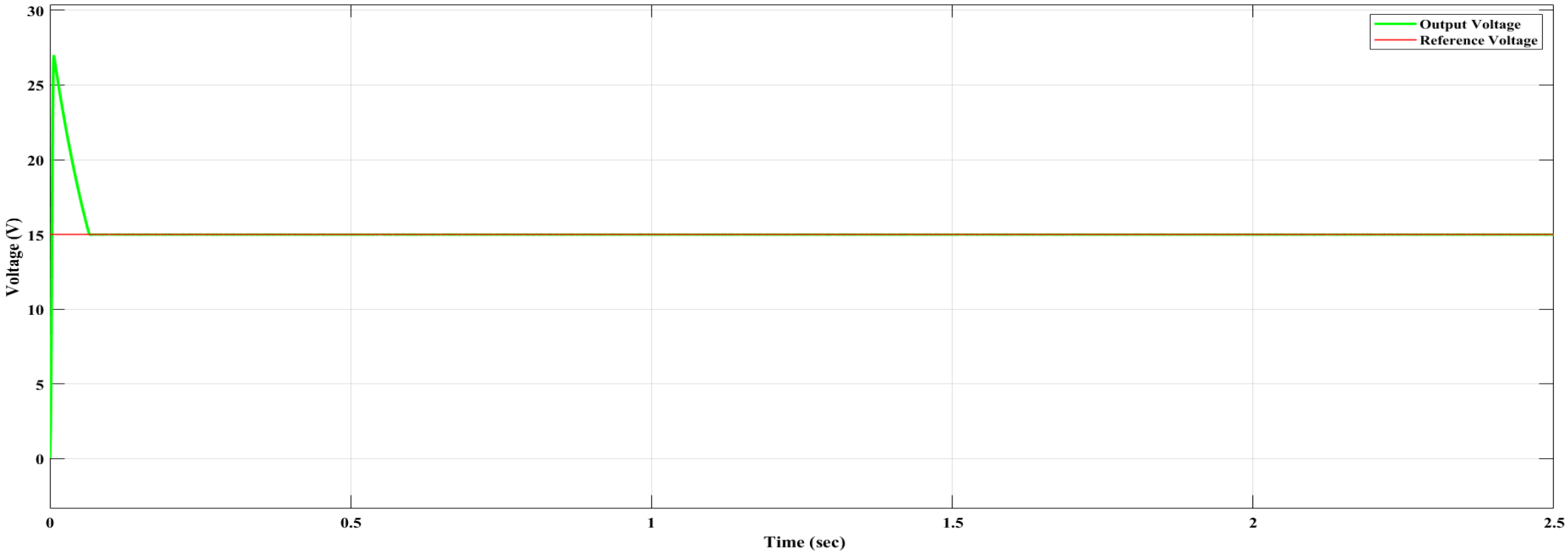

**Voltage mode controlled buck converter**

# Controller




Controller

# Output Voltage and Ref Voltage



# Transfer functions

Converter transfer function:

$$G1(s) = \frac{3000000}{s^2 + 10s + 1000000}$$

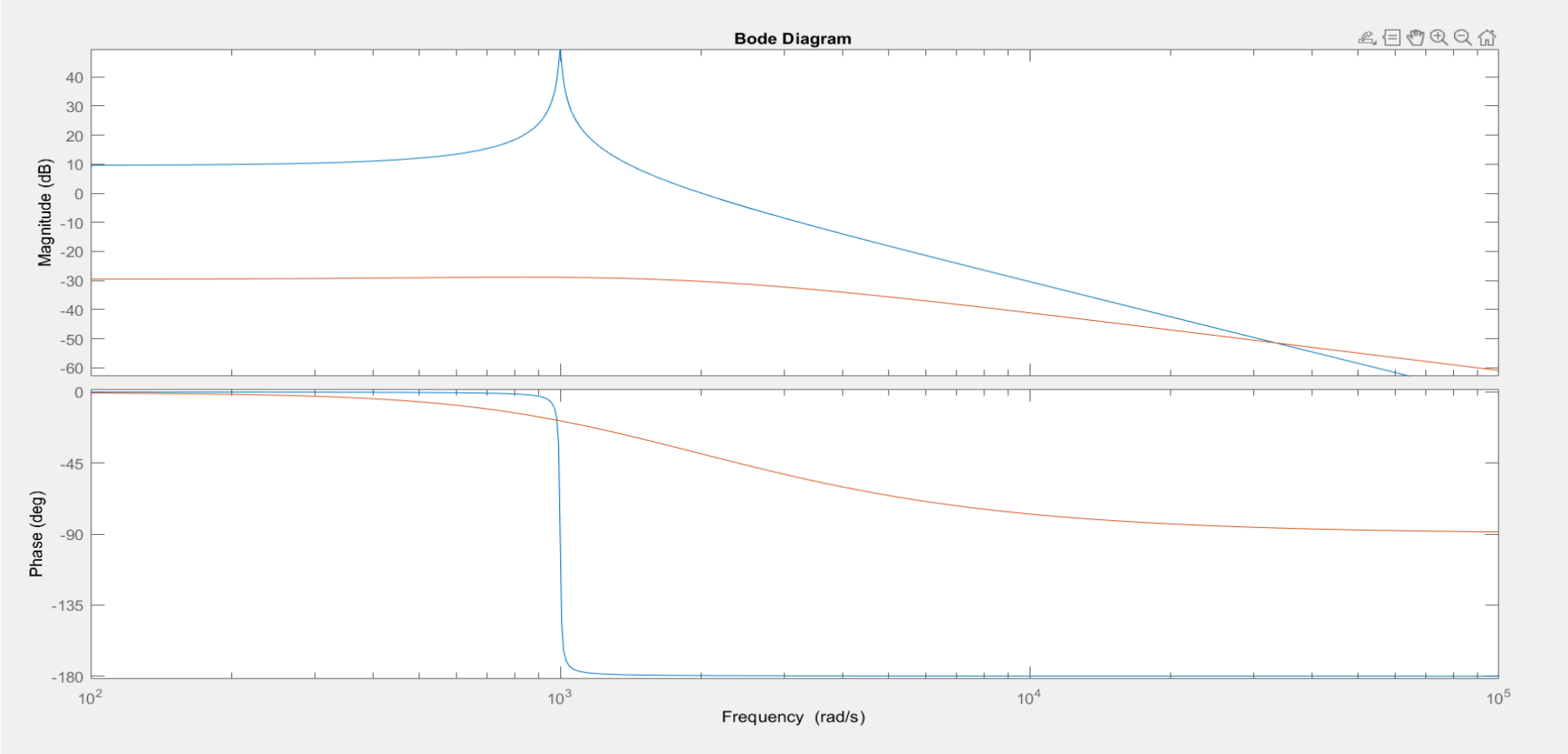
Controller transfer function:

$$G2(s) = \frac{s^2 + 2900s + 1800000}{90s + 60000}$$

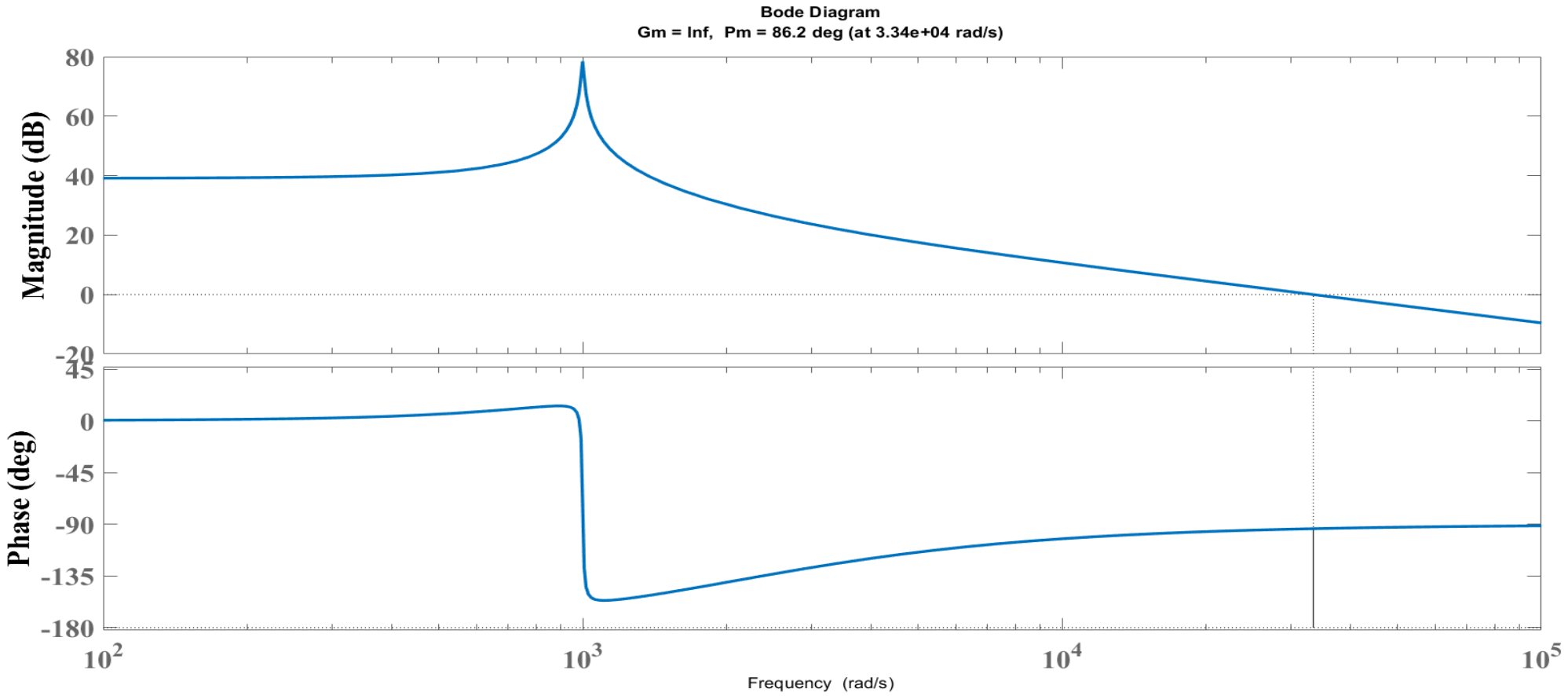
Open loop transfer function:

$$G(s) = G1(s) * G2(s) = \frac{3000000s^2 + 8700000000s + 540000000000}{90s^3 + 60900s^2 + 90600000s + 60000000000}$$

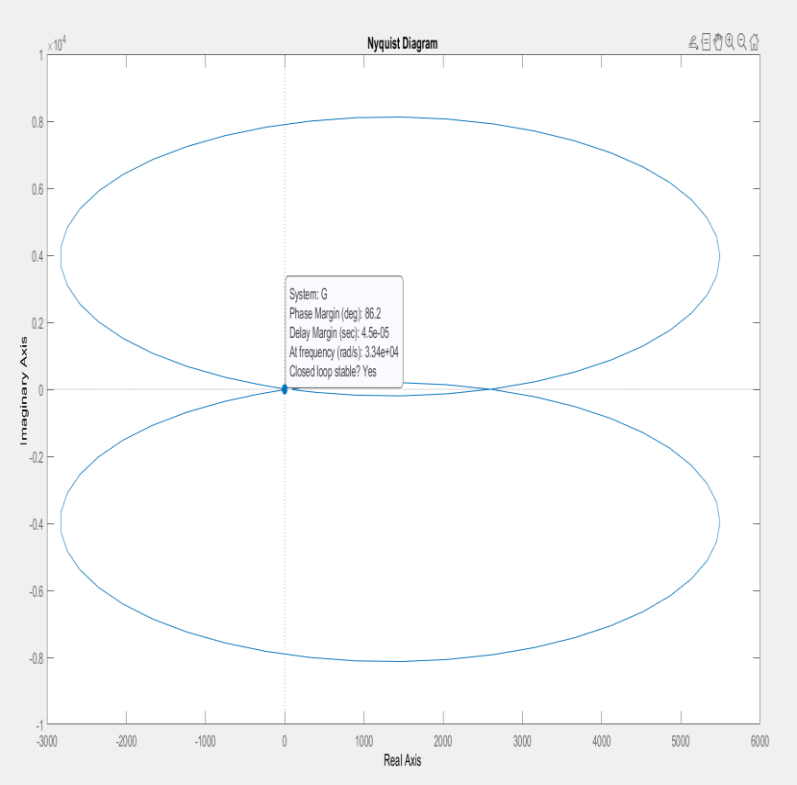
# Bode plots

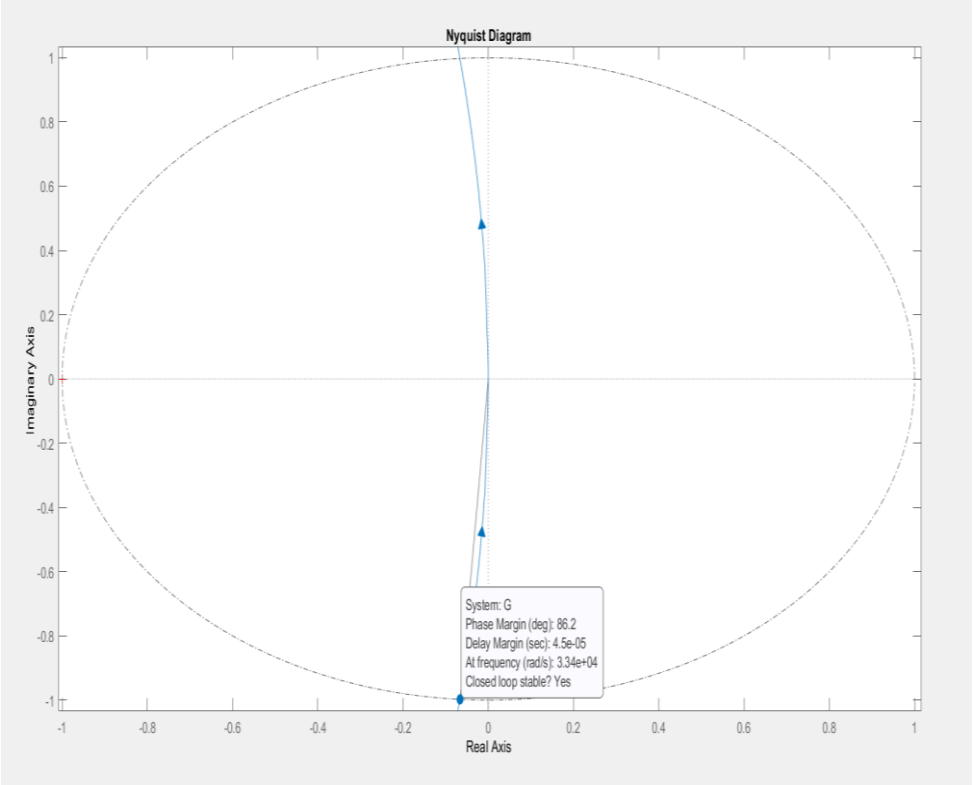

Bode Diagram
Magnitude (dB)
40
30
20
10
0
-10
-20
-30
-40
-50
-60
Phase (deg)
0
-45
-90
-135
-180
$10^2$
$10^3$
$10^4$
$10^5$
Frequency (rad/s)

# Bode plot of system with controller



# Nyquist plot



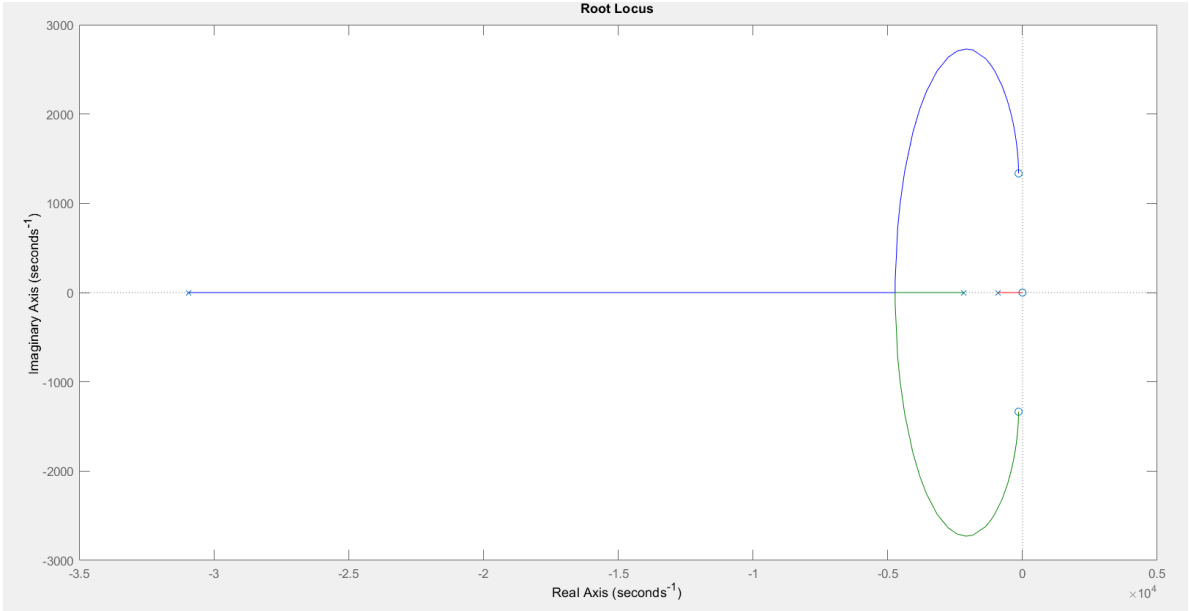
# Transfer function with esr

$$G2(s) = \frac{s^2 + 2900s + 1800000}{90s + 60000}$$

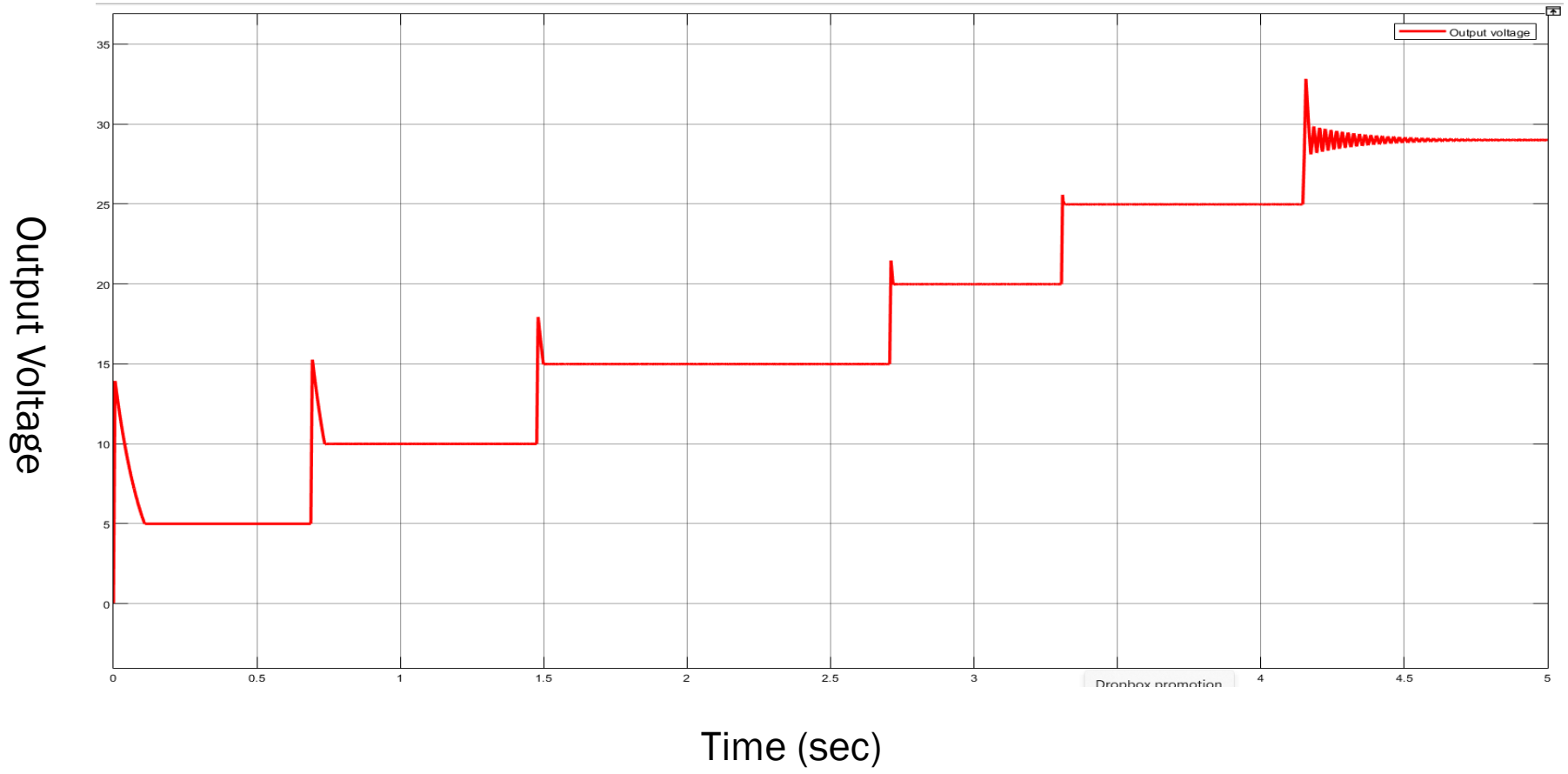
$$\frac{V_o}{d} = \frac{V_{in}(1 + s * r * C) * G_c}{L * C * \left(s^2 + s\left(\frac{1}{R * C} + \frac{r}{L}\right) + \frac{1}{L * C}\right)}$$

$$M(s) = \frac{100 * s^3 + 29030 * s^2 + 1.802 * 10^8 * s}{3 * s^3 + 102030 * s^2 + 2.903 * 10^8 * s + 1.802 * 10^{11}}$$

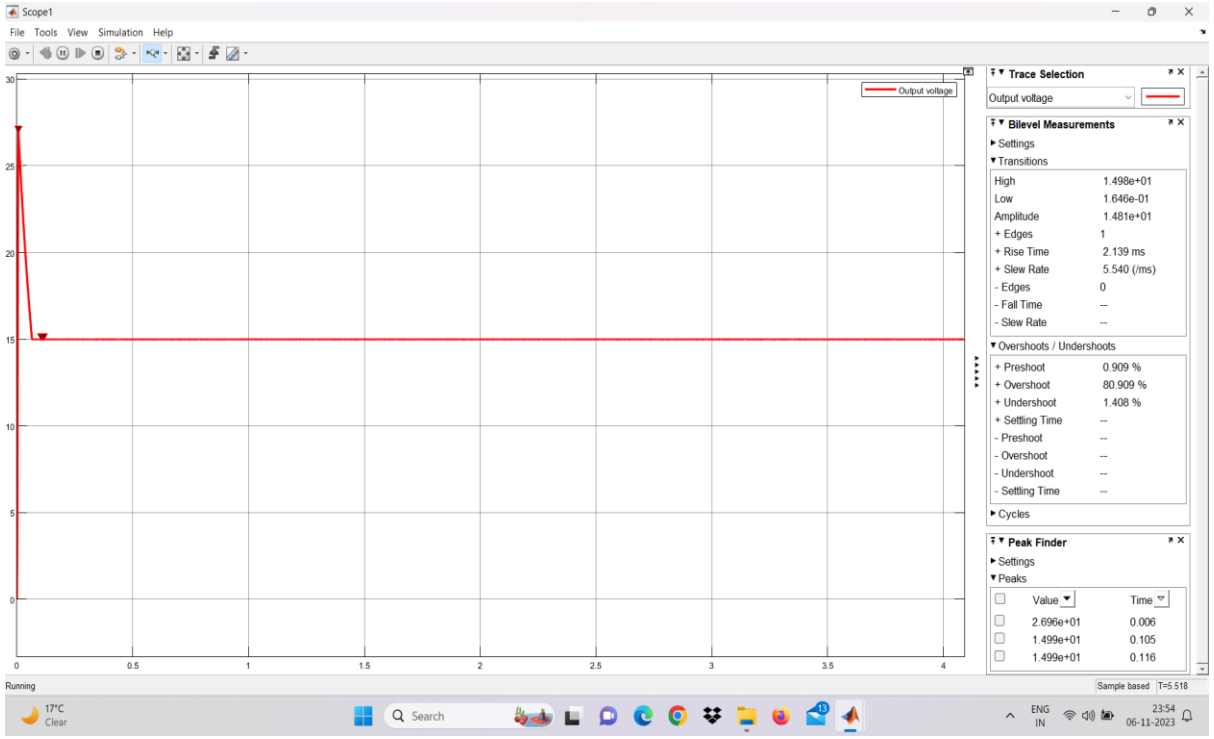
# Root locus

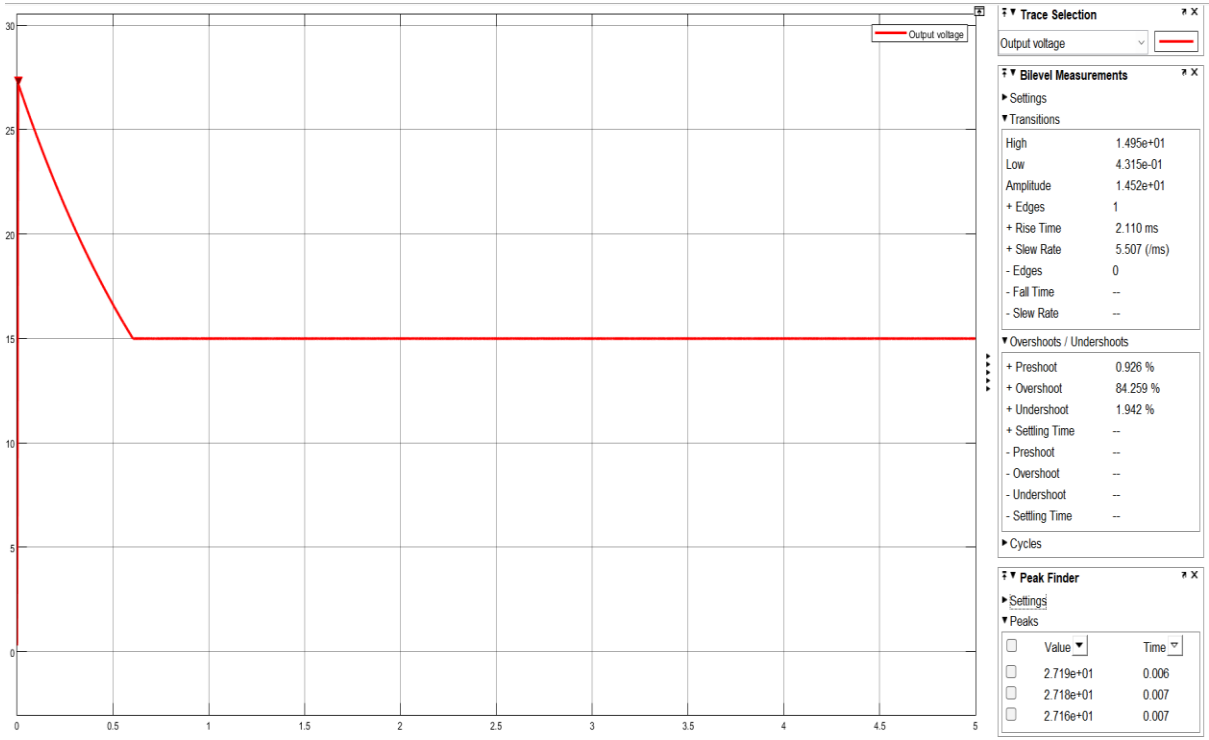

Root Locus
Imaginary Axis (seconds$^{-1}$)
Real Axis (seconds$^{-1}$)
3000
2000
1000
0
-1000
-2000
-3000
-3.5
-3
-2.5
-2
-1.5
-1
-0.5
0
0.5
$\times 10^4$

# Output Voltage waveforms for different values of Ref Voltage

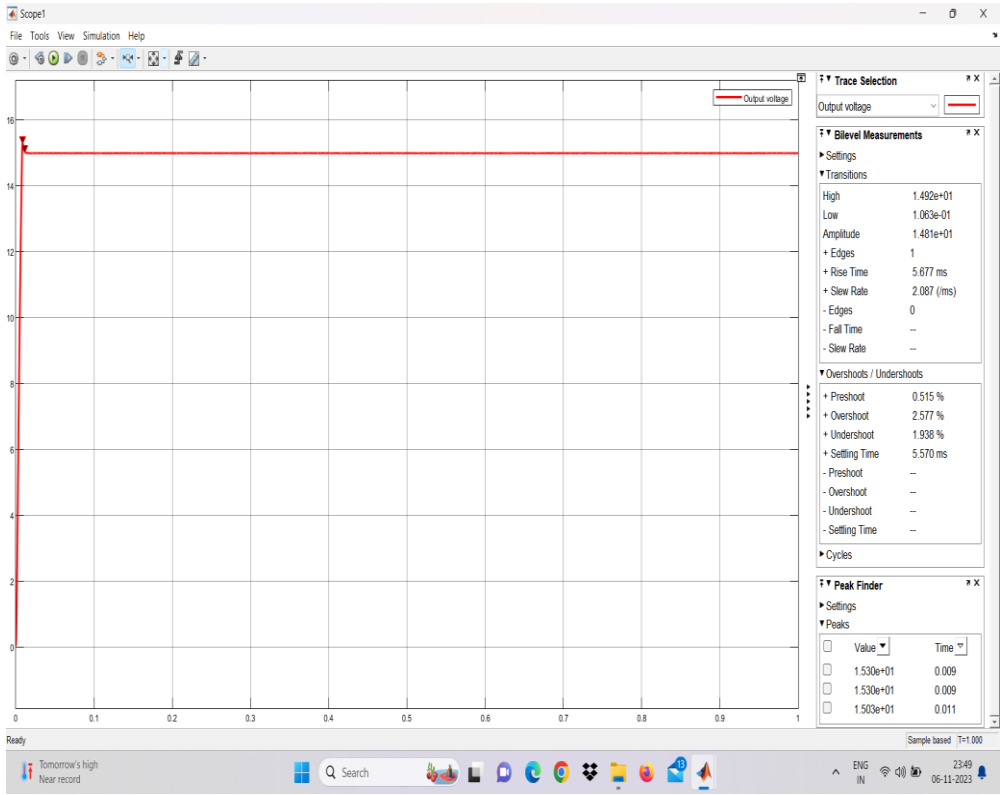


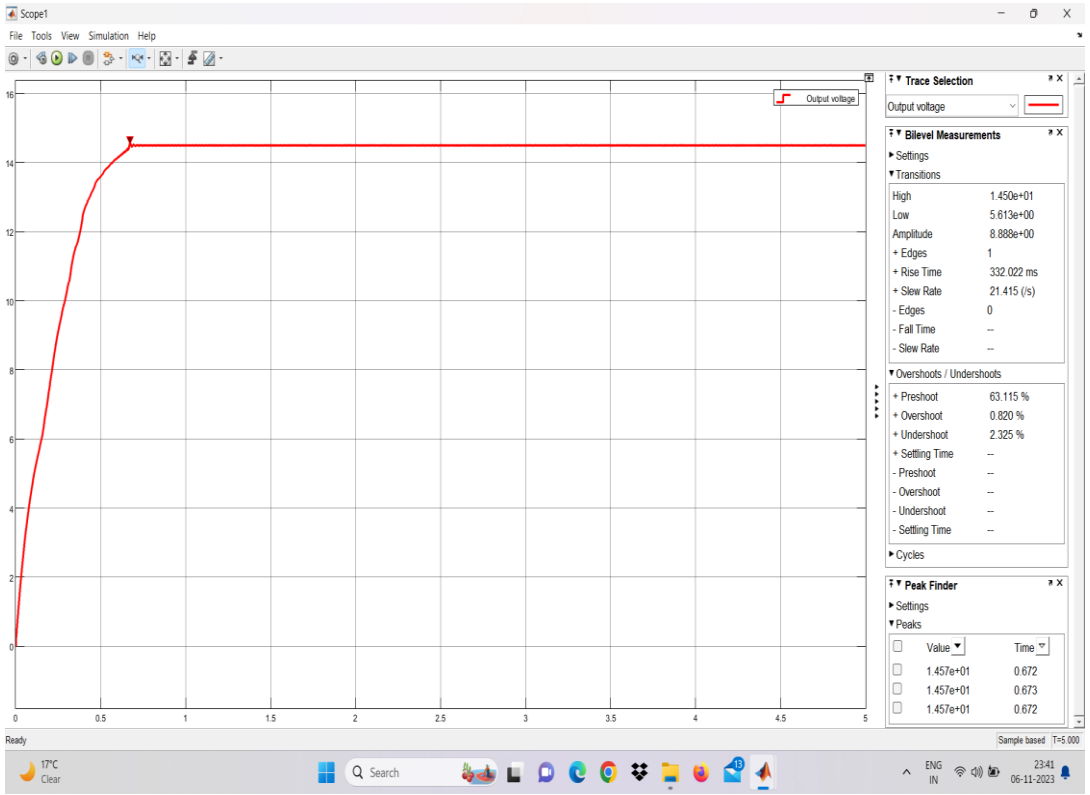
# Output voltage variation with resistance



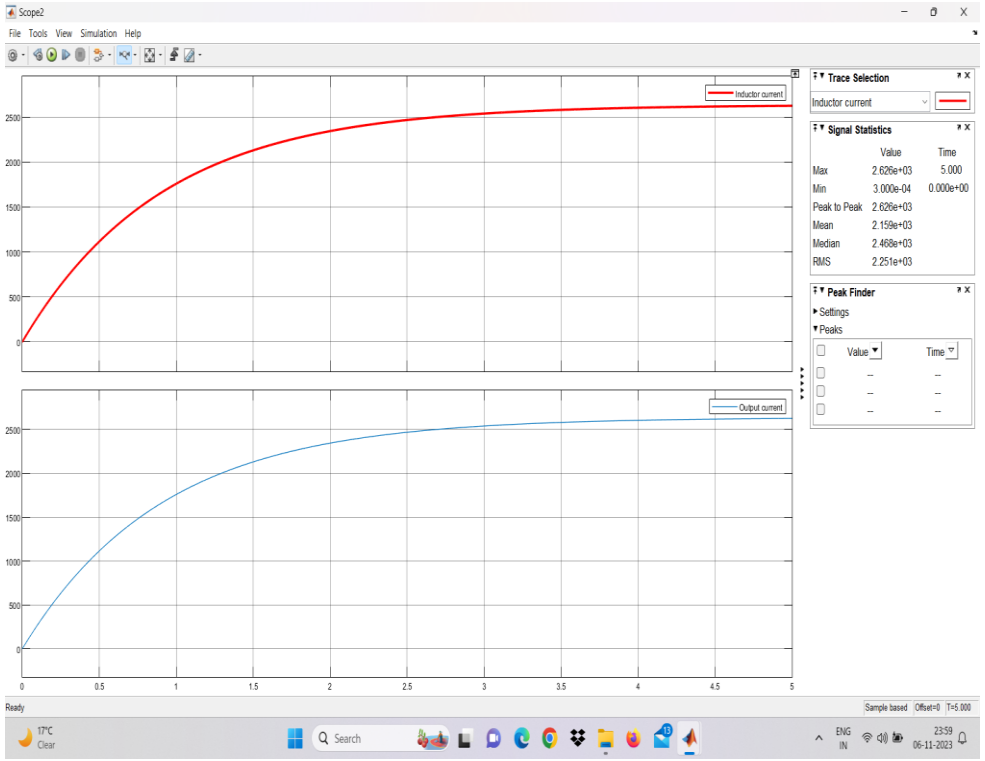



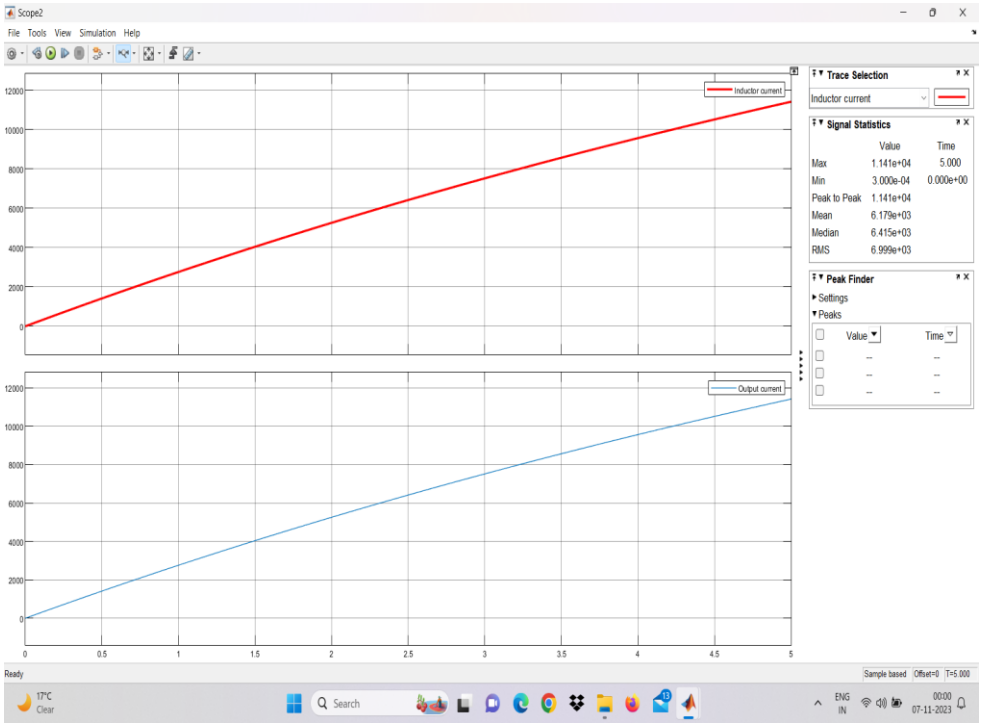
# Output voltage variation with inductor resistance



# Inductor and output current during short circuit condition



# EXPLANATIONS OF QUESTION ASKED DURING PRESENTATION

Q.) What is the reason behind increase in rise time with increase in ESR of inductor?

A.) An increase in ESR increases the value of damping ratio which in turn reduces the value of rise time according to the following formula.

$$t_r = \frac{\pi - \theta}{w_n \sqrt{1 - \zeta^2}}$$

# Thank You