

MIDDLE EAST TECHNICAL UNIVERSITY

Electrical & Electronics Engineering

Simulation Project #2

EE 463

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Introduction

In this project, we are asked to design and simulate

Q1)

Q2) DC Motor Drive

a.

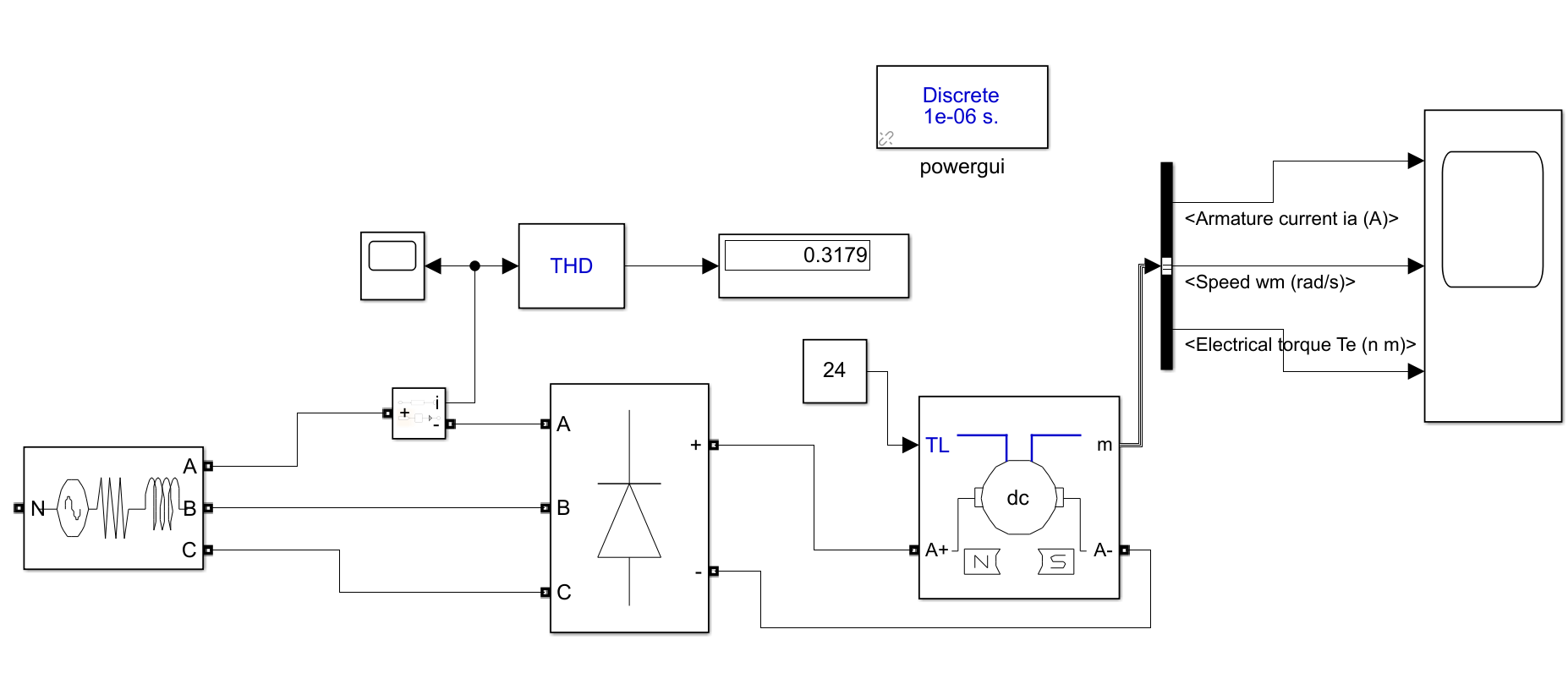


Figure : Circuit simulated DC motor drive

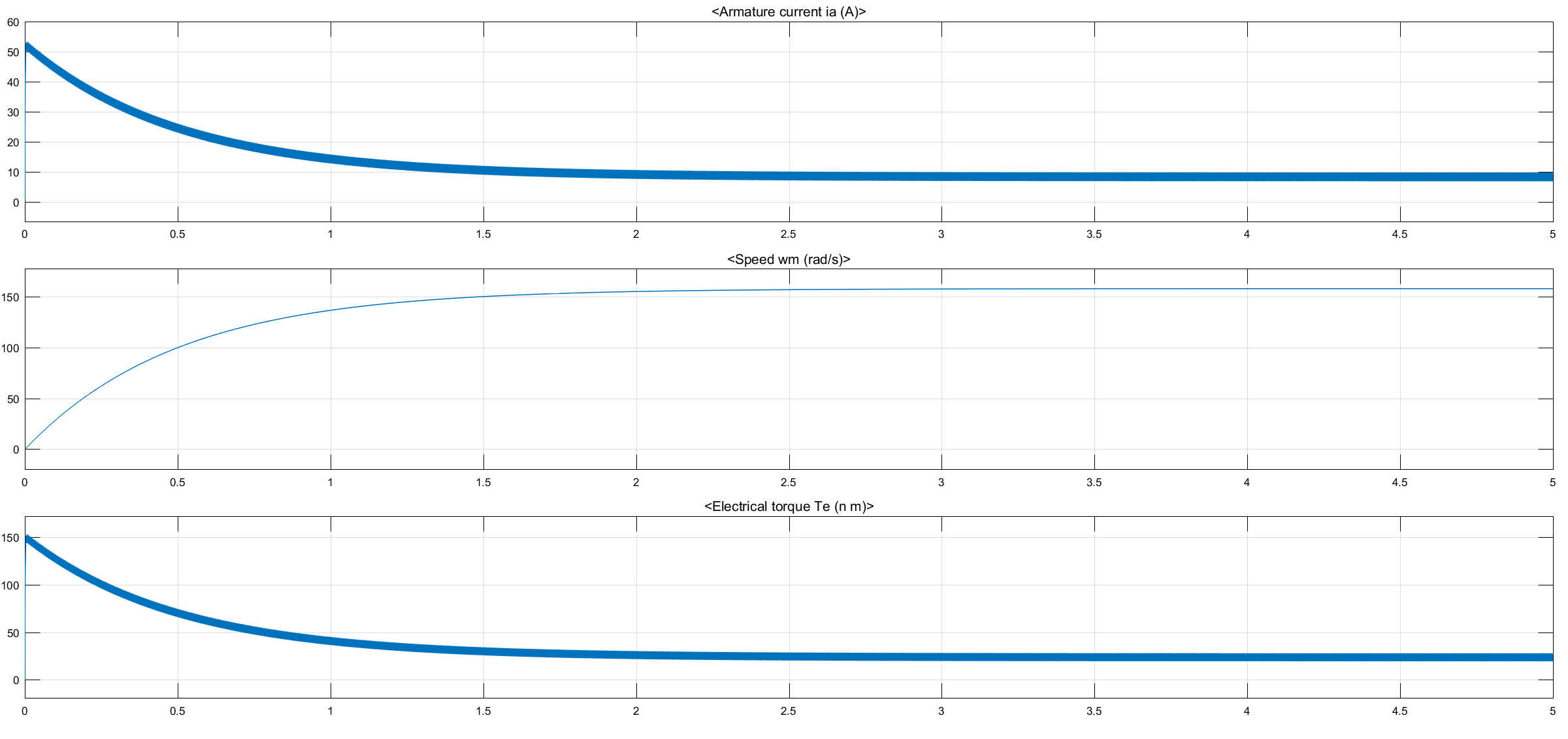


Figure : Armature Current, Speed and Electrical Torque waveforms

b. Note that THD is calculated and displayed on Figure ?? as %31.8

We want to drive our DC motor with a constant DC voltage. However, we have 3Ɵ full-bridge rectifier for DC rectification. As known, 3Ɵ full-bridge rectifier is the reason we have ripple at the output voltage, current and thus torque waveforms.

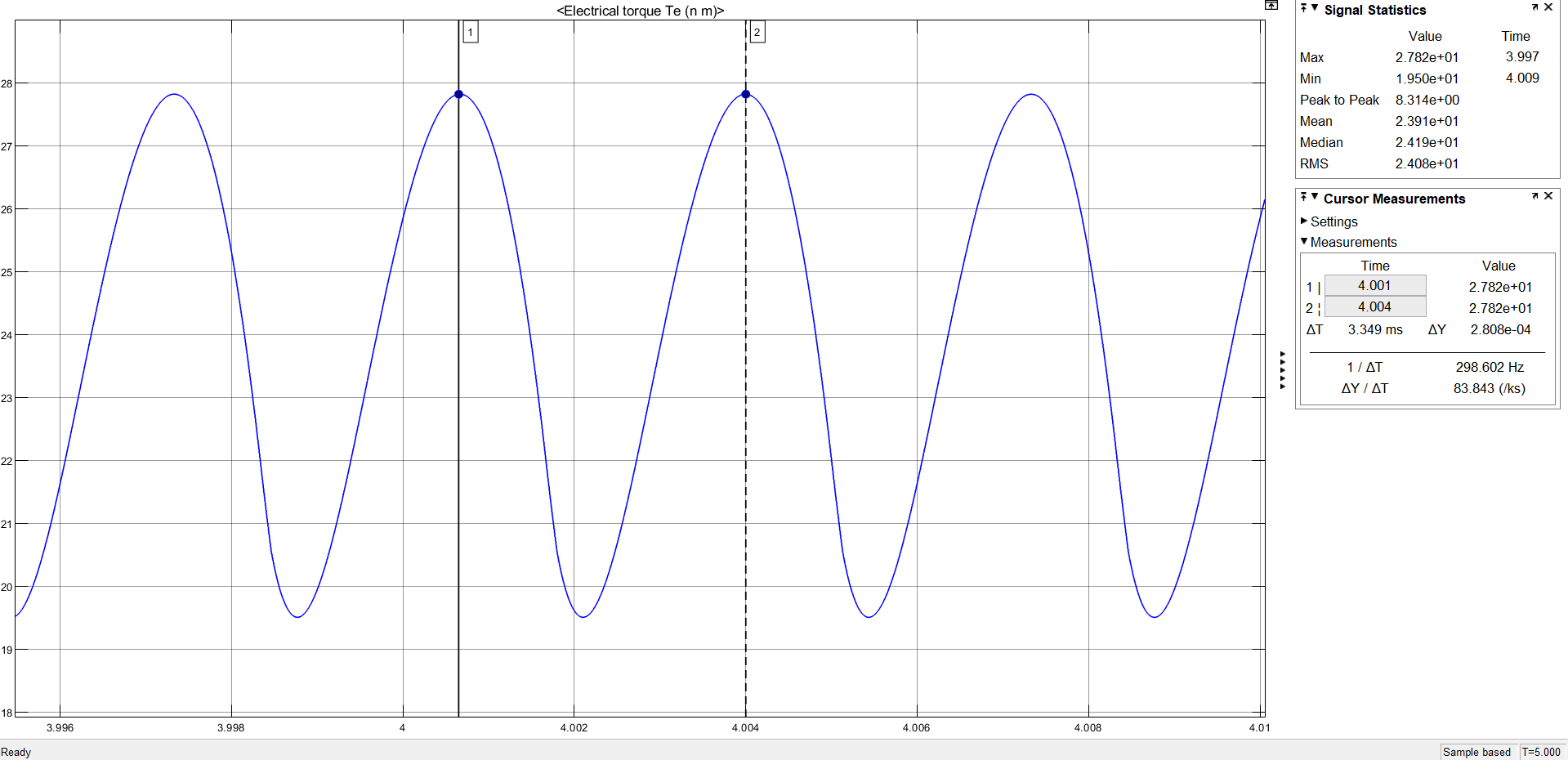


Figure : Electrical Torque waveform

In Figure ??, torque waveform is illustrated at steady state. When the cursor measurements are done, we see that torque waveform has 299Hz frequency. We expect it to be happen because at the output of 3Ɵ full-bridge rectifier, we have 6 pulses in each cycle which corresponds to 50Hz\*6=300Hz.

In magnitude case, the ripple is considerably high which oscillates between 19.5Nm to 27.5Nm where the average is 24Nm. The ripple is more than %10. In practice, it may cause problems and it should be decreased to a reasonable value.

c. To reduce the ripple, we can connect a parallel capacitor to load or connect a series inductor to load. By this way, we can reduce the output torque ripple by smoothing the current waveform and hence torque.

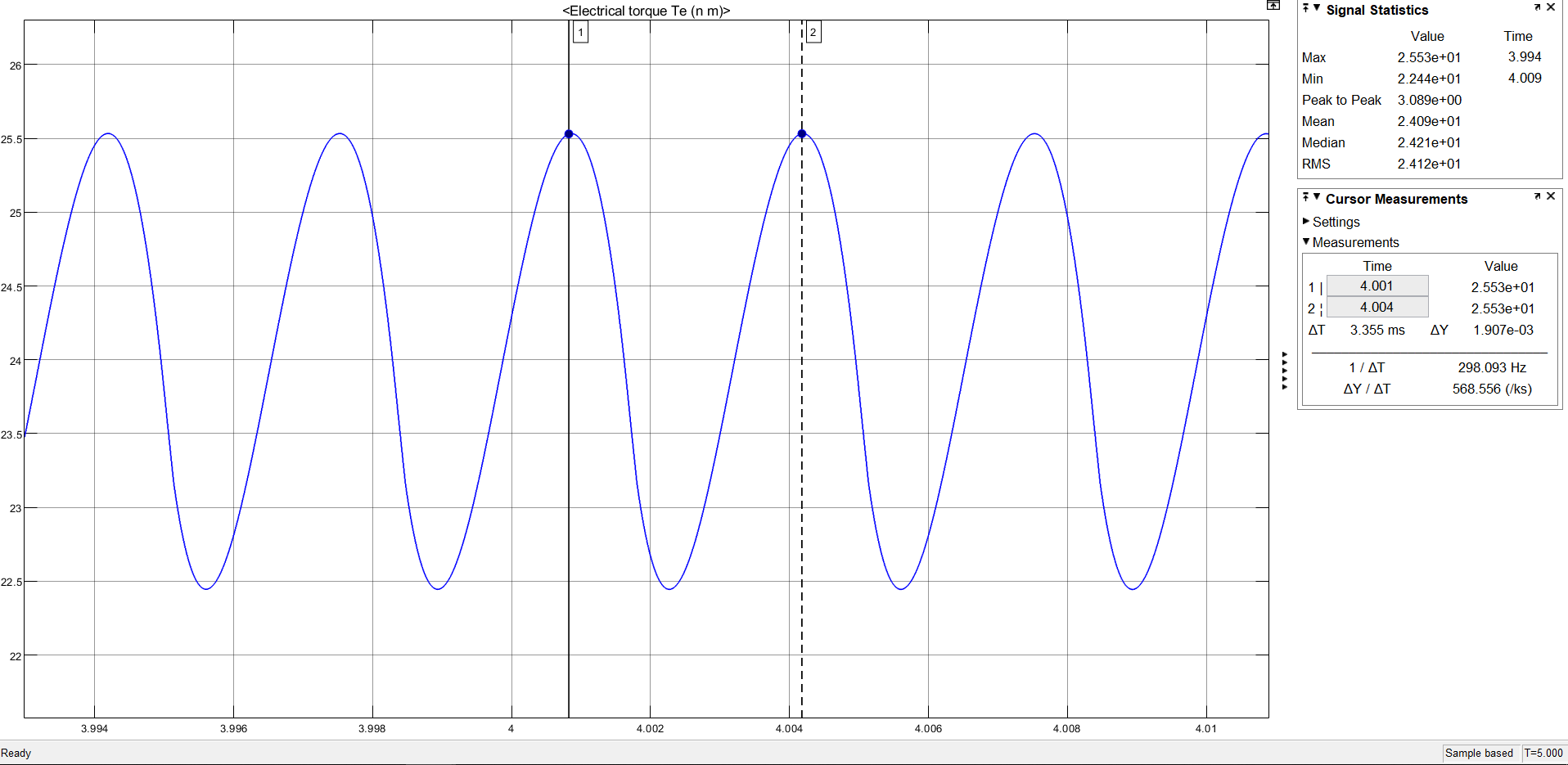


Figure : Electrical Torque waveform with L = 0.02H

As shown in Figure??, a series connection of L=0.02H reduces torque ripple about %6.

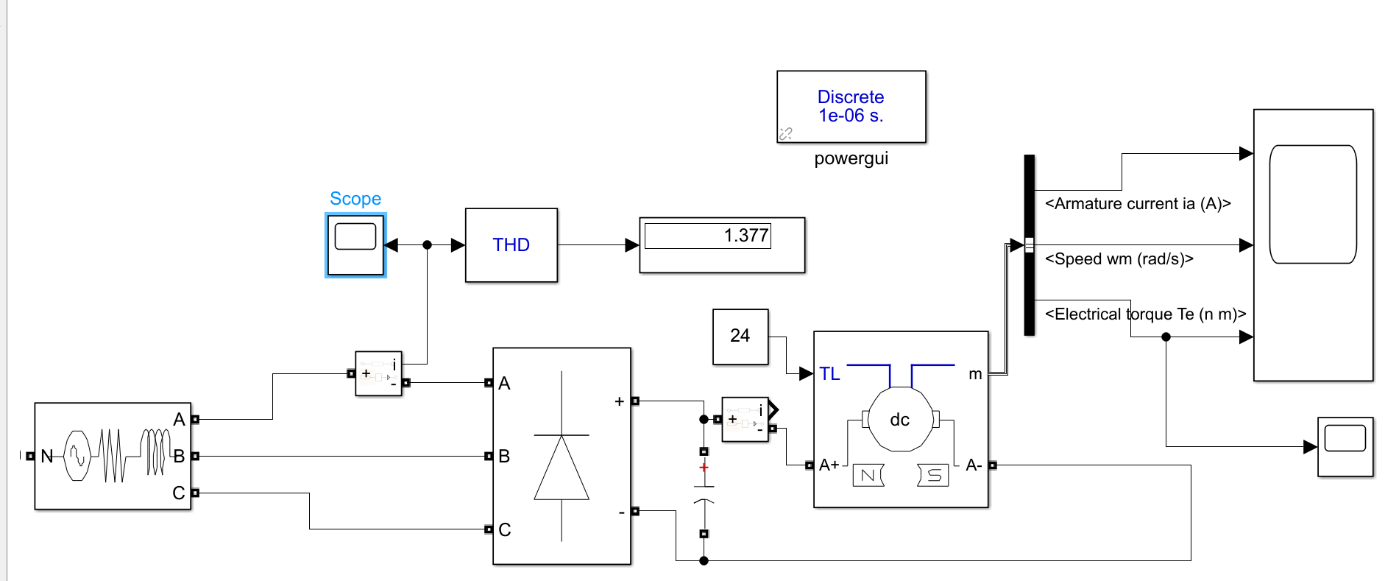


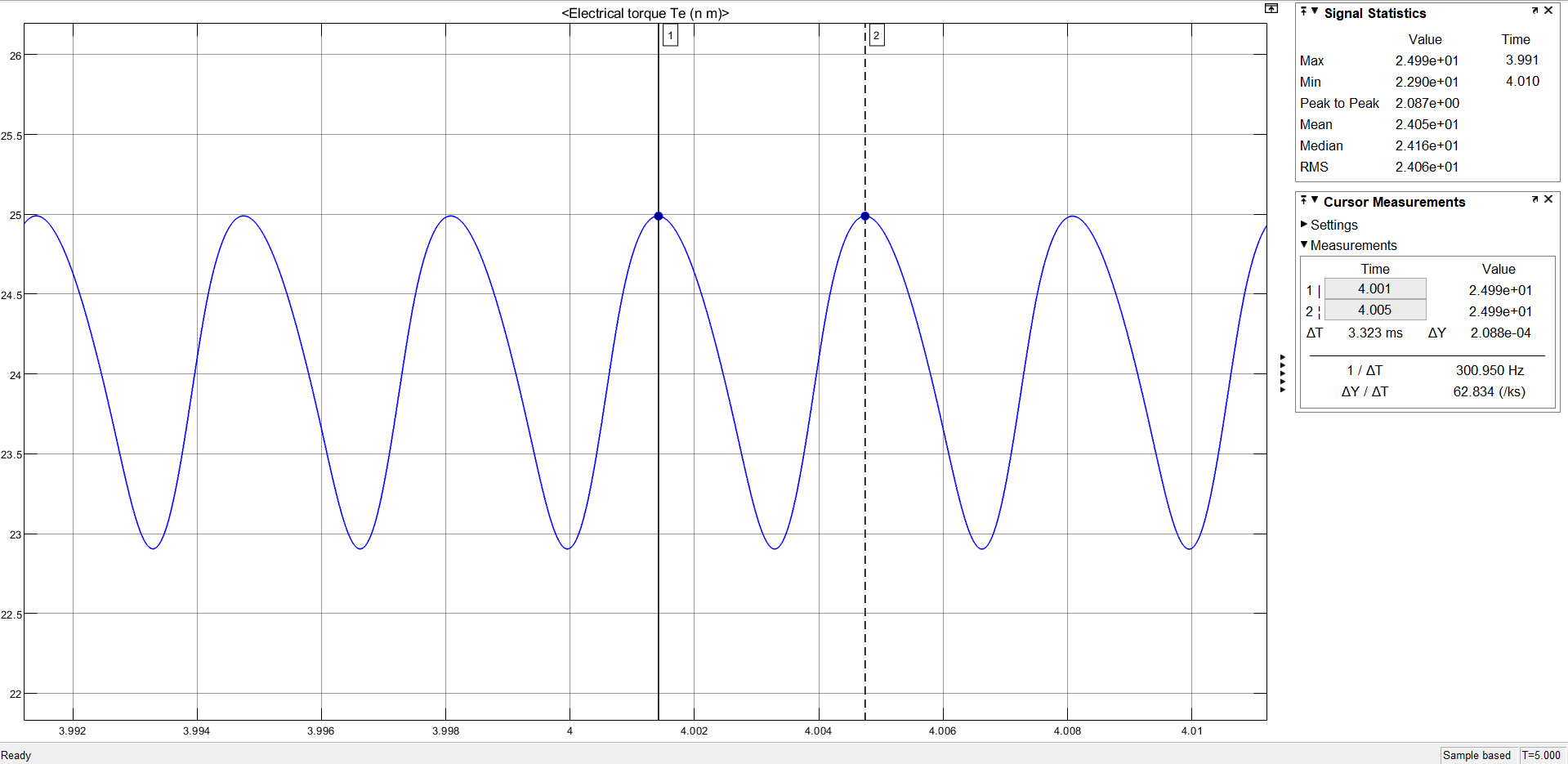
Figure ???: Circuit simulated with parallel capacitor of 1mF

Figure : Electrical Torque waveform with C = 1mF

As shown in Figure??, a parallel connection of C = 1mF reduces torque ripple about %4.

Although adding a parallel capacitor decreases the ripple at the output, it increases the THD to %137 which is shown in circuit schematic illustrated in Figure ???.

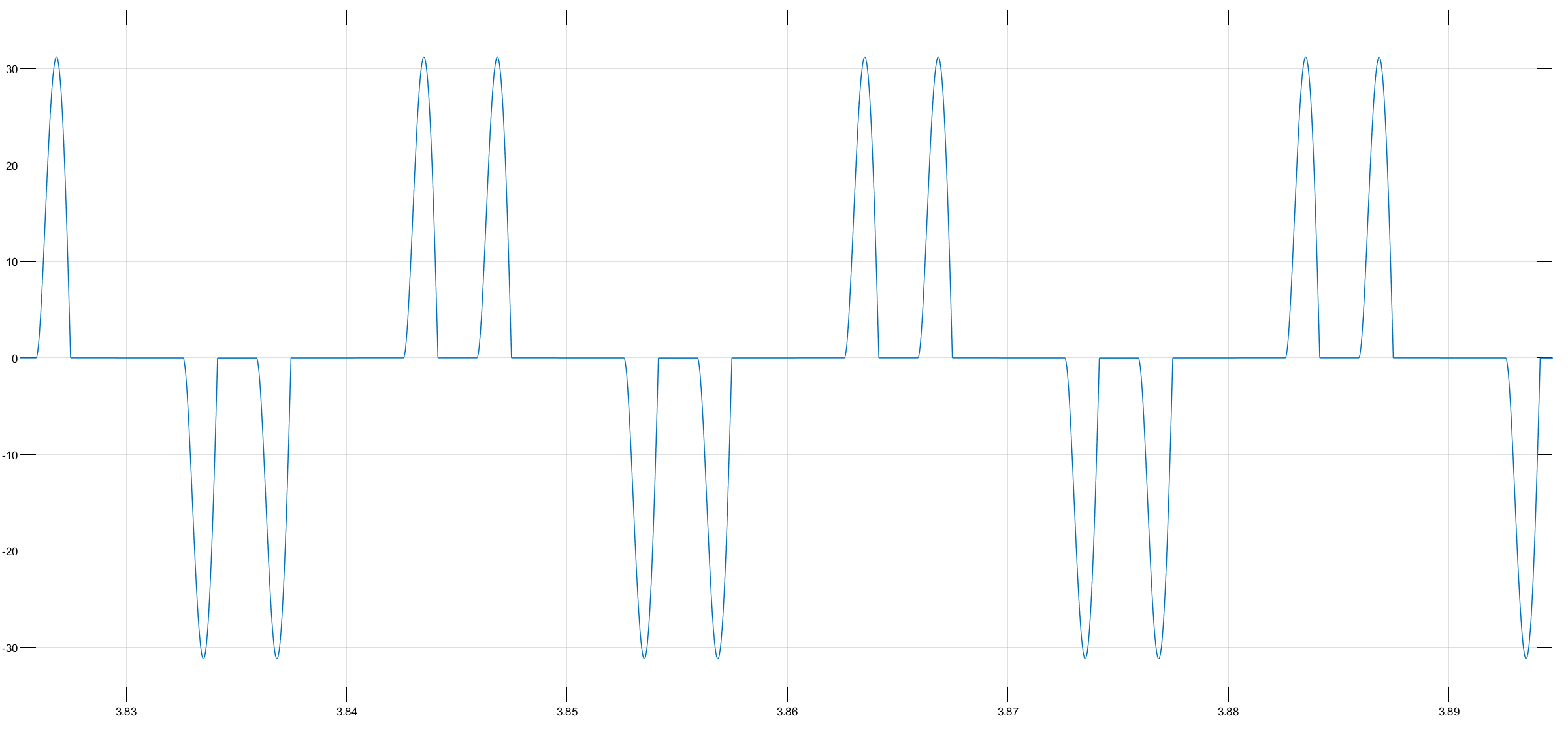


Figure ??: Current waveform when C=1mF is connected

Current waveform of the source side is illustrated in Figure ??. We do not prefer parallel capacitor connection because it increases the THD and current waveform is not desirable.

By connecting an extra circuit component, we can reduce the ripple torque which enables us to have more reliable torque characteristics for motor. Having smoother waveform is also important for mechanical concerns. If we have too much ripple at torque output, shaft of motor cannot be durable comparing with less ripple torque case.

What we trade-off here is adding an extra component to circuit. This increases the conduction losses. Also, for higher voltage values as in our case, we need to implement high voltage and current capacity elements which is directly related with the sizes of components. Having bigger components is hard for implementing circuit into board. Furthermore, it is harder to cool the system with bigger sized components. THD consideration and current waveforms are stated before.

d. Note that following values are calculated at steady state. Current, speed and voltage values are found from graphical analysis on Simulink. All values are approximated accordingly.

Input power = 3\*Single-Ɵ Power input = 3\*230V\*7A = 4830W

Output mechanical power = T\*w = 24Nm\*164.5rad/sec = 3948W

Drive efficiency = 3948W/4830W = %82

For loss calculations;

Power on Source Side = 4764W

Loss on Source Side = 4830W-4764W = 66W

Output Power of Rectifier = 4738W

Then, loss on Rectifier = 4764W- 4738W = 26W

Armature loss = Output Power of Rectifier – Output Mechanical Power

= 4738W-3948W =790W

Q3)

References

[1] *Bridge Rectifier Ripple Voltage*. Retrieved from <https://www.electronics-tutorials.ws/diode/diode_6.html>

[2] Mohan, N., Undeland, T. M., & Robbins, W. P. (2002). *Power electronics: Converters, applications, and design*. New York: John Wiley.