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Subject Name: HVDC

Subject Code: EEP 424

Assignment (2) | Bipolar Point-To-Point HVDC-Link | MATLAB Model

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# I. System Description:

- A 1600MW 6-pulse bipolar point-to-point HVDC-link shown below. The link interconnects between two AC networks, (network (A): 22kV/50Hz, network (B):20kV/60Hz), through overhead transmission line with a resistance of 10 Ω. The range of firing angle at the rectifier side is (5deg-25deg), while the inverter is operated under minimum γ of 20deg. 1:10 Y-Y ideal transformers with zero leakage inductances are employed. Proper smoothing reactors (Lsr) are employed as shown.

A diagram of a power line

Description automatically generated

# II. Six-Pulse Model:

## Question (A):

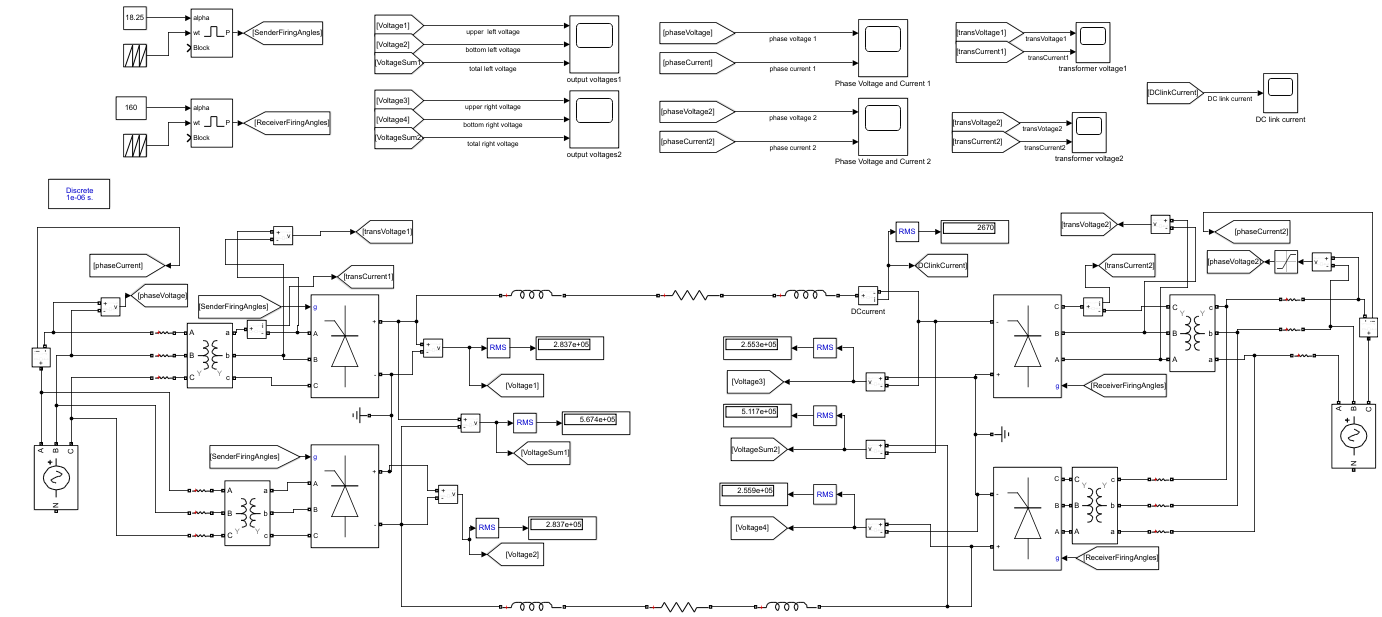
#### Transferring a power of 1600 MW from side (A) to side (B) during normal operating conditions. Find analytically the suitable firing angle at the rectifier side, and the corresponding dc current.

#### Transferring a power of 1200 MW from side (B) to side (A) during normal operating conditions. Find analytically the suitable firing angle at the rectifier side, and the corresponding dc current. (Assume -10% tapping at inverter side, and +10% tapping rectifier side).

#### Transferring a power of 1600MW from side (A) to side (B) during 2.5% voltage swell at network (A).

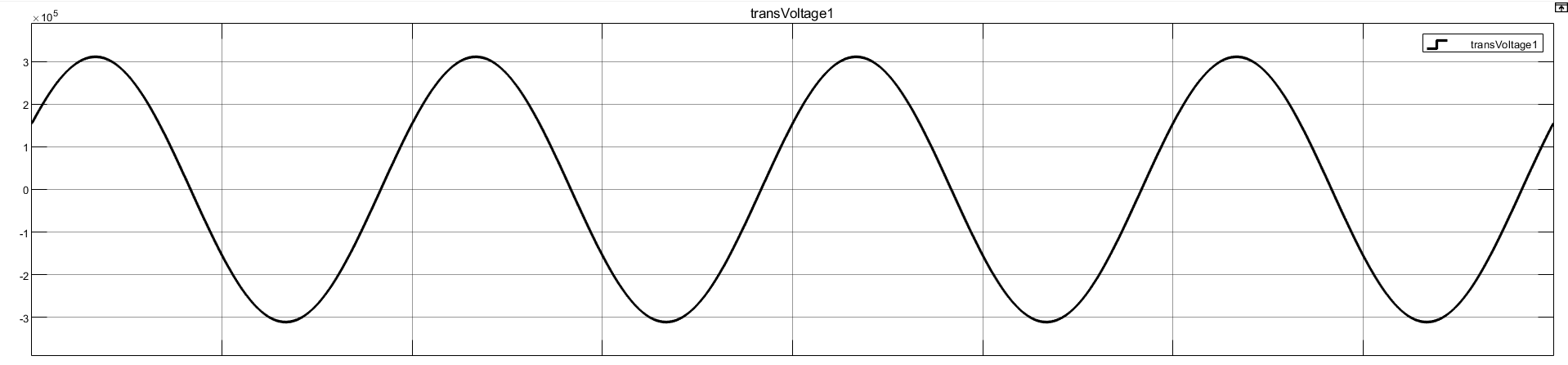
## Question (B):

### Model Screenshot:



### Case (1): 1600MW: Power flow from (A) to (B): Net(A) is rectifier and Net(B) is inverter:

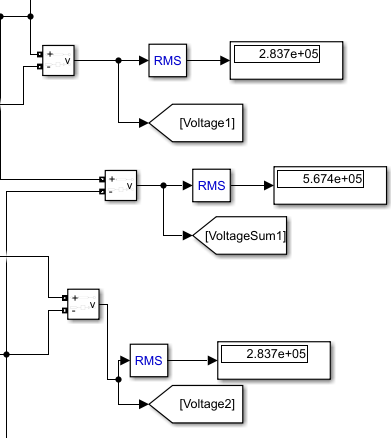
#### AC voltage at rectifier side:



#### Vdor: DC voltage at rectifier side:

A graph of a graph

Description automatically generated

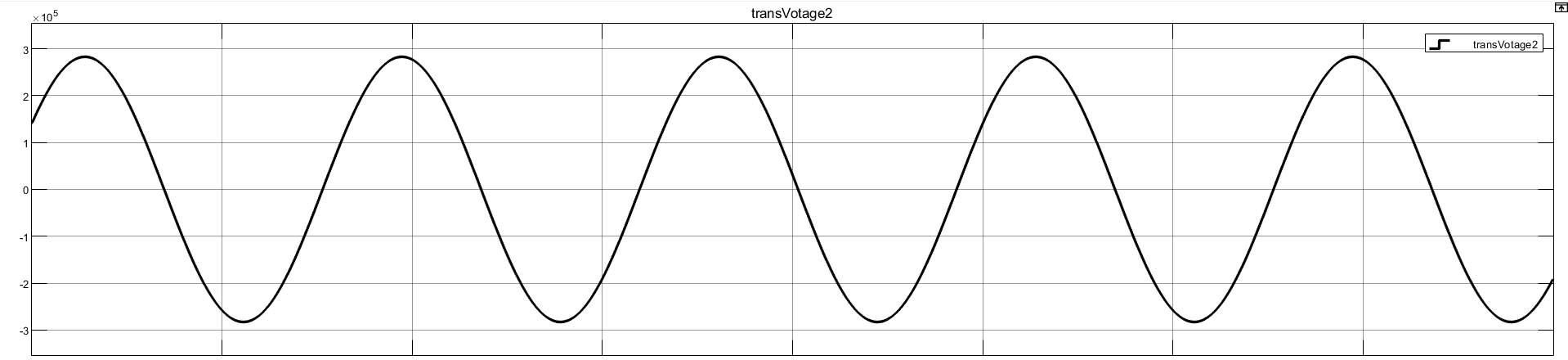


#### Grid current at rectifier side:

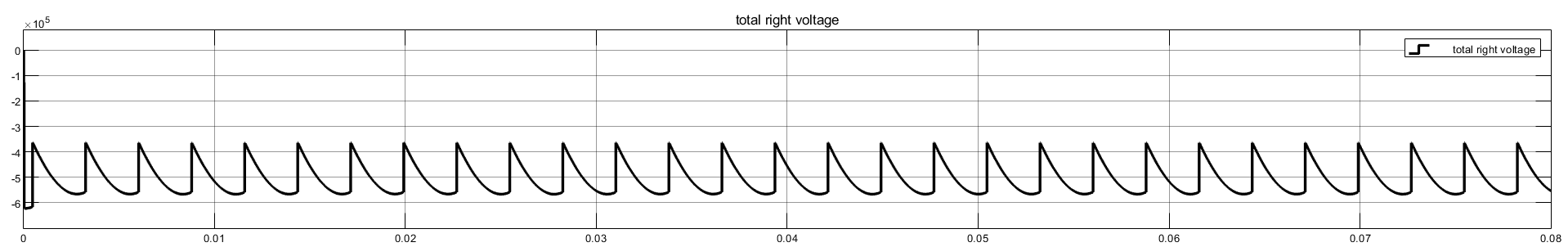
A diagram of a building

Description automatically generated with medium confidence

#### AC voltage at inverter side:



#### Vdoi: DC voltage at inverter side:



A diagram of a computer

Description automatically generated

#### Grid current at inverter side:

A diagram of a line

Description automatically generated

#### DC current (L=0.1 Henry):

A graph of a graph

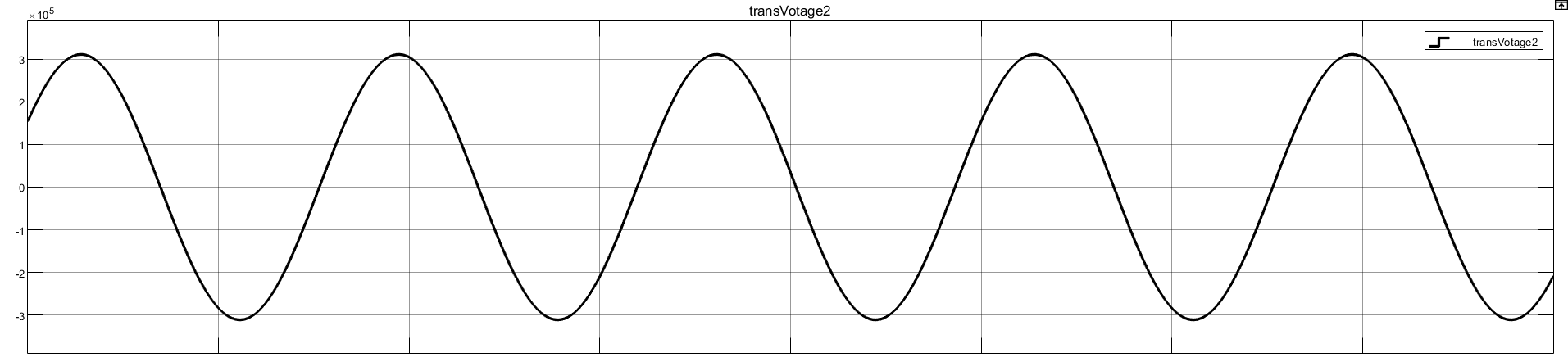
Description automatically generated

A diagram of a computer system

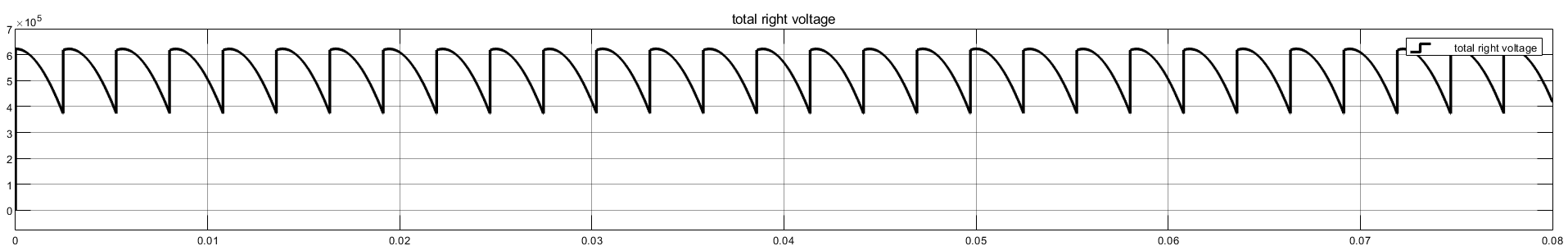
Description automatically generated

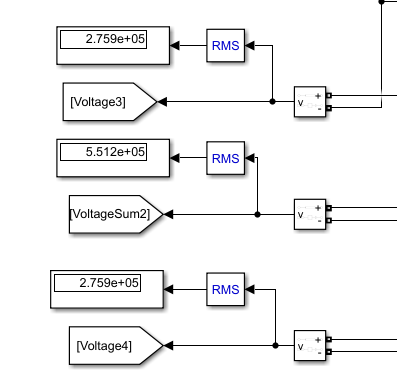
### Case (2): 1200MW: Power flow from (B) to (A): Net(B) is rectifier (+10%) and Net(A) is inverter (-10%):

#### AC voltage at rectifier side:

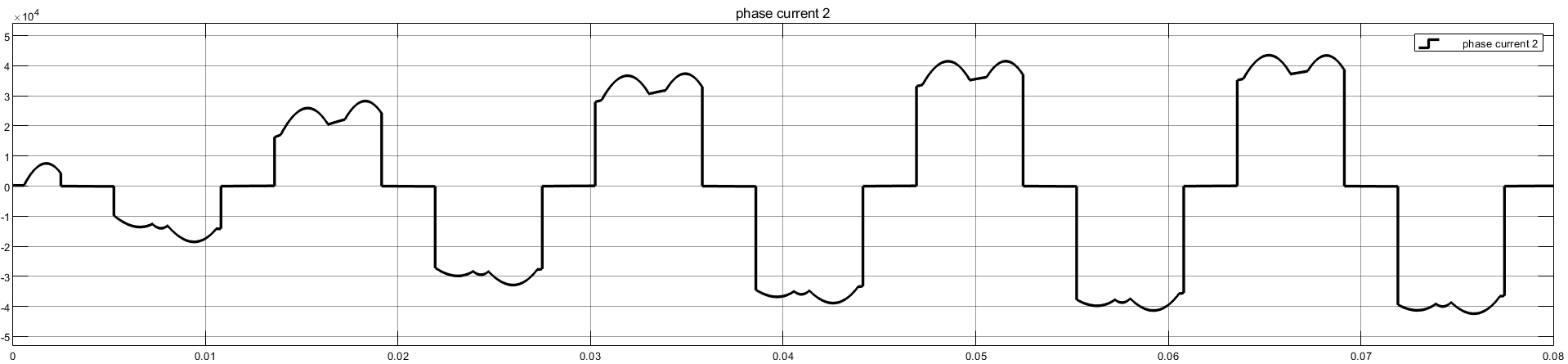


#### Vdor: DC voltage at rectifier side:





#### Grid current at rectifier side:



#### AC voltage at inverter side:

A graph of a function

Description automatically generated

#### Vdoi: DC voltage at inverter side:

A graph of a graph

Description automatically generated

A diagram of a computer

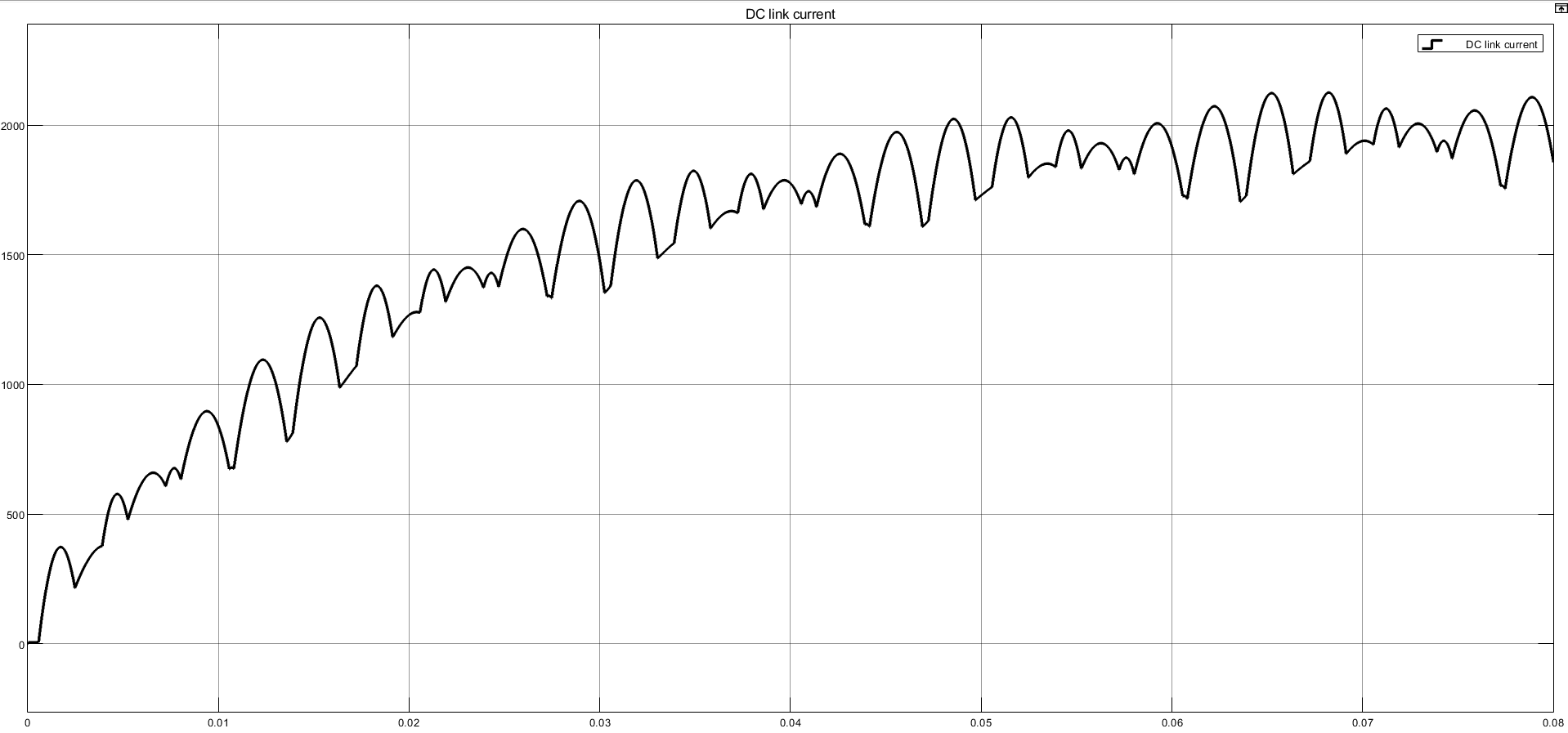
Description automatically generated

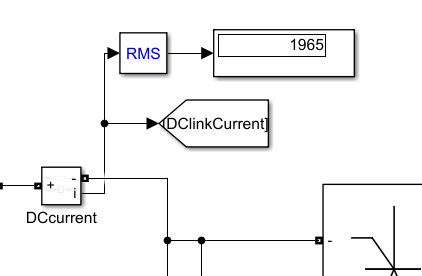
#### Grid current at inverter side:

A diagram of a waveform

Description automatically generated

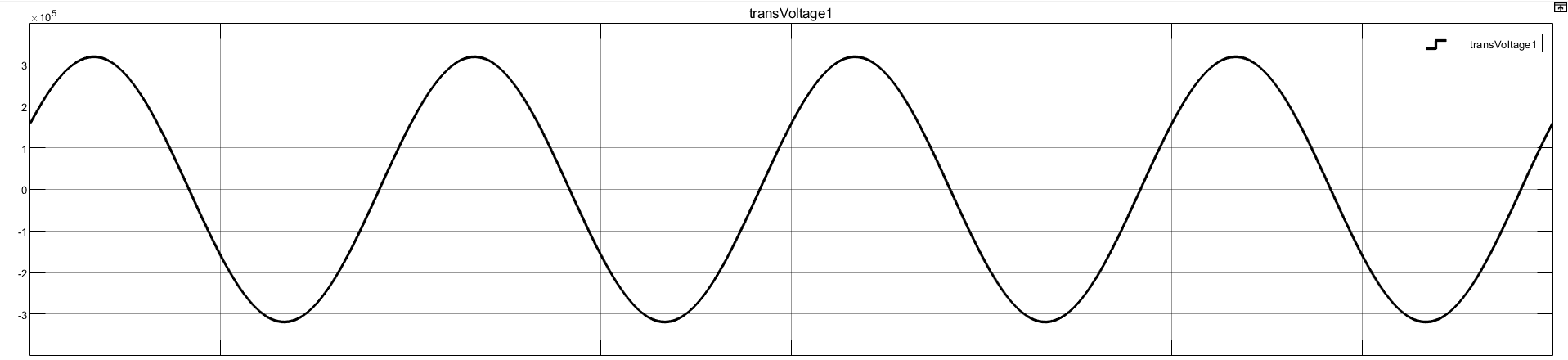
#### DC current (L=0.1 Henry):



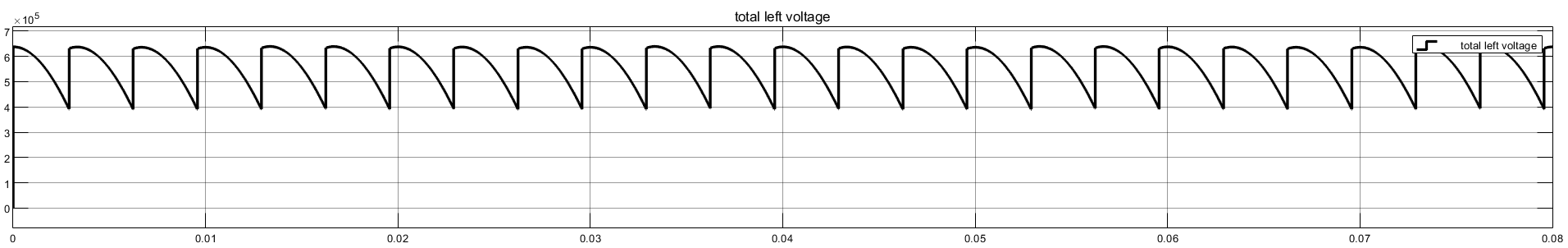


### Case (3): 1600MW: Power flow from (A) to (B): Net(A) is rectifier (2.5% voltage swell) and Net(B) is inverter:

#### AC voltage at rectifier side:



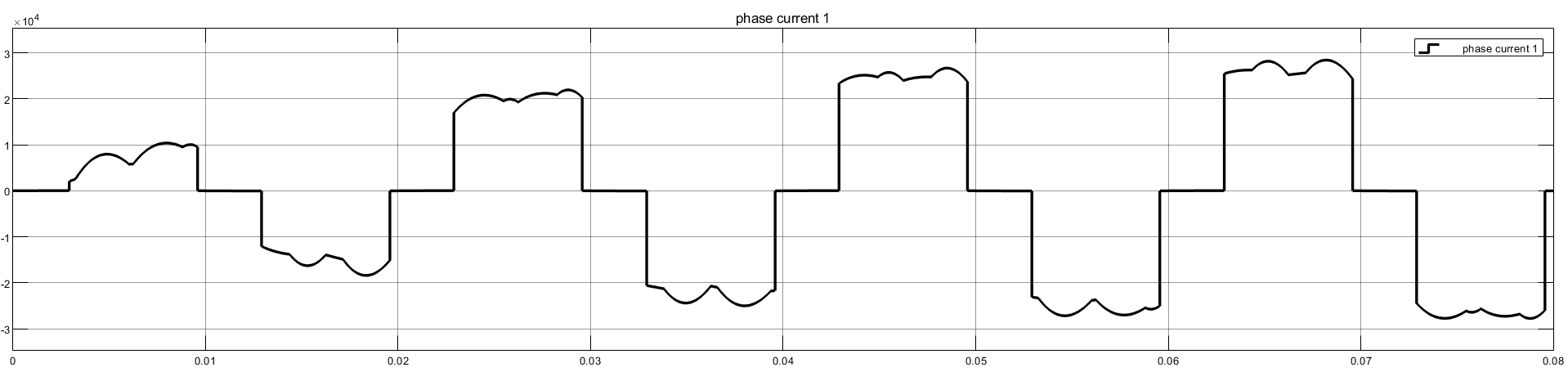
#### Vdor: DC voltage at rectifier side:



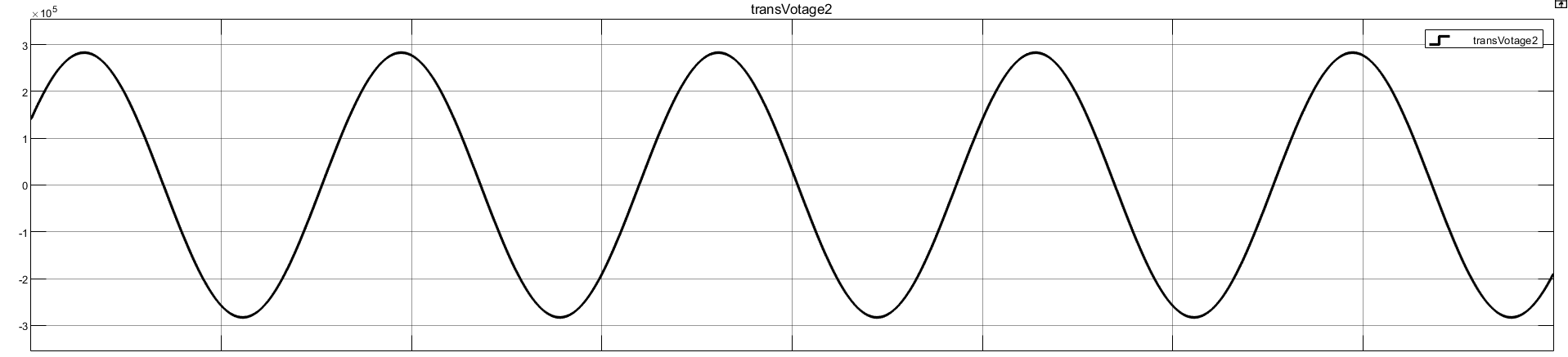
A diagram of a machine

Description automatically generated

#### Grid current at rectifier side:



#### AC voltage at inverter side:



#### Vdoi: DC voltage at inverter side:

A graph of a wave

Description automatically generated

A diagram of a computer

Description automatically generated

#### Grid current at inverter side:

A diagram of a diagram

Description automatically generated with medium confidence

#### DC current (L=0.1 Henry):

A graph of a function

Description automatically generated

A diagram of a computer program

Description automatically generated

# III. Twelve-Pulse Model:

## Question (C):

### Model Screenshot:

A diagram of a computer program

Description automatically generated

### Case (1): 1600MW: Power flow from (A) to (B): Net(A) is rectifier and Net(B) is inverter:

#### Analytical Calculations:

- Since alpha ( here is more than 25 degrees, the maximum permissible limit, I will work with changing the tap transformer ratio to -5% to go back to the allowable range of (5🡪25degrees); working with -2.5% exceeded the upper range too ().

#### AC voltage at rectifier side:

A graph of a function

Description automatically generated

#### Vdor: DC voltage at rectifier side:

A black line on a white background

Description automatically generated

A diagram of a voltage

Description automatically generated

#### Grid current at rectifier side:

A graph of a line graph

Description automatically generated with medium confidence

#### AC voltage at inverter side:

A graph of a function

Description automatically generated

#### Vdoi: DC voltage at inverter side:

A black and white drawing of a spiral

Description automatically generated

A diagram of a circuit diagram

Description automatically generated

#### Grid current at inverter side:

A graph of a building

Description automatically generated

#### DC current (L=0.1 Henry):

A graph of a graph

Description automatically generated

A diagram of a computer

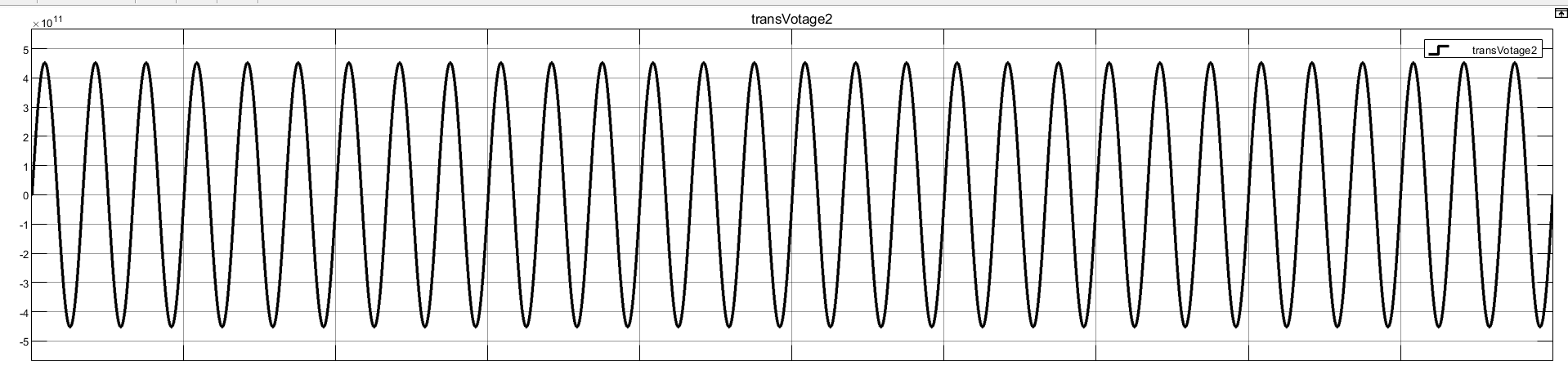
Description automatically generated

### Case (2): 1200MW: Power flow from (B) to (A): Net(B) is rectifier (+10%) and Net(A) is inverter (-10%):

#### Analytical Calculations:

🡪 Higher than maximum limit but transformer tapping ratio is already modified I don’t know…

#### AC voltage at rectifier side:



#### Vdor: DC voltage at rectifier side:

A black line on a white background

Description automatically generated

A diagram of a machine

Description automatically generated

#### Grid current at rectifier side:

A graph of a graph

Description automatically generated with medium confidence

#### AC voltage at inverter side:

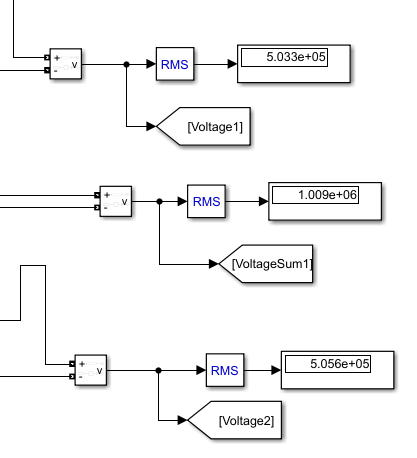
A black lines on a white background

Description automatically generated

#### Vdoi: DC voltage at inverter side:

A black and white line

Description automatically generated

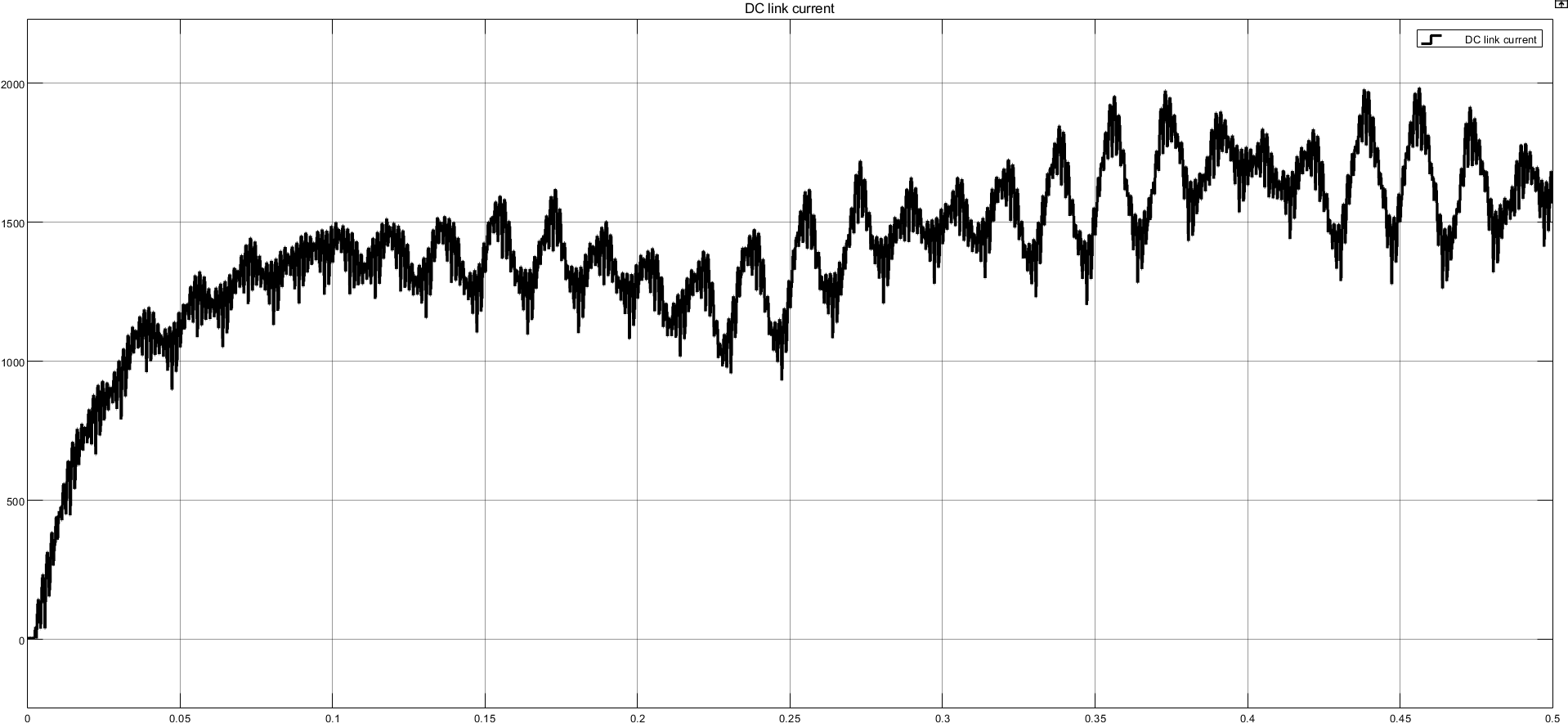


#### Grid current at inverter side:

A graph of a graph

Description automatically generated with medium confidence

#### DC current (L=0.1 Henry):



A diagram of a computer system

Description automatically generated

### Case (3): 1600MW: Power flow from (A) to (B): Net(A) is rectifier (2.5% voltage swell) and Net(B) is inverter:

#### Analytical Calculations:

- Again, alpha exceeds the limit, but I will leave it for now...

#### AC voltage at rectifier side:

A graph of a graph

Description automatically generated with medium confidence

#### Vdor: DC voltage at rectifier side:

A drawing of a line

Description automatically generated

A diagram of a voltage diagram

Description automatically generated with medium confidence

#### Grid current at rectifier side:

A graph of a line

Description automatically generated with medium confidence

#### AC voltage at inverter side:

A black lines on a white background

Description automatically generated

#### Vdoi: DC voltage at inverter side:

A graph of a graph

Description automatically generated with medium confidence

A diagram of a circuit

Description automatically generated

#### Grid current at inverter side:

A graph of a graph

Description automatically generated with medium confidence

#### DC current (L=0.1 Henry):

A graph showing a wave

Description automatically generated

A diagram of a computer system

Description automatically generated

# IV. Comparison:

### Question (D):

#### Compare the performance of 6-pulse and 12-pulse converters. Comment.

* 12-pulse instead of 6-pulse are obtained due to the 30 degrees shift between star and delta windings and so a smoother ripple-less voltage is obtained. This results in reduced size filters and lower cost.

A graph of a graph

Description automatically generated

A black line on a white background

Description automatically generated

* It is also observed that the grid currents at both sides (rectifier and inverter) are enhanced, now curves are closer to the sine wave in a 10-pulse shape) as shown below in curves. (sample curves from 12-pulse case (1)).

A diagram of a graph

Description automatically generated

A graph of a line

Description automatically generated with medium confidence

# V. Attachments:

* [GitHub repo.](https://github.com/Tasnime1/HVDC-model)