Lab 3: Torque Control of Permanent-Magnet Synchronous Motors

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# Introduction:

# Results:

## Part 1: ZeroID

|  |  |
| --- | --- |
| Motor Efficiency (%) | 93.59 |
| Power Extracted (Pbat) | 51.56 |
| Average Torque | 192 |
| SS Trq Ripple | 0.004078 |
| U Control Load | 0.00471 |
| Current THD | 0.05156 |
| Torque Tracking Error | 0.0136 |

A screenshot of a computer program

Description automatically generated

A graph of a graph

Description automatically generated with medium confidence

A graph with a line

Description automatically generated

A graph with a line

Description automatically generated

A graph with a red line

Description automatically generated.

## MTPA Control:

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.86 |
| Power Extracted (Pbat) | 50.31 |
| Average Torque | 191.9 |
| SS Trq Ripple | 0.02252 |
| U Control Load | 0.005088 |
| Current THD | 0.04193 |
| Torque Tracking Error | 0.1048 |

A diagram of a machine

Description automatically generated with medium confidence

A graph of a graph

Description automatically generated with medium confidence

A graph with a black line

Description automatically generated

A graph with a line

Description automatically generated

A graph with a line

Description automatically generated

A graph with a red line

Description automatically generated

## MTPA Control: Gain applied to PsiF

|  |  |
| --- | --- |
| Motor Efficiency (%) | 96.14 |
| Power Extracted (Pbat) | 43.7 |
| Average Torque | 167.2 |
| SS Trq Ripple | 0.02448 |
| U Control Load | 0.006085 |
| Current THD | 0.04702 |
| Torque Tracking Error | 24.71 |

A diagram of a machine

Description automatically generated

A graph with a colorful line

Description automatically generated with medium confidence

A graph on a screen

Description automatically generated

A graph with a line

Description automatically generated

A graph with a line drawn on it

Description automatically generated

A graph with a red line

Description automatically generated

## MTPA Control: Step Change

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.39 |
| Power Extracted (Pbat) | 63.19 |
| Average Torque | 239.9 |
| SS Trq Ripple | 0.02619 |
| U Control Load | 0.00407 |
| Current THD | 0.03741 |
| Torque Tracking Error | 0.02755 |

A screenshot of a computer program

Description automatically generated

A graph with a red line

Description automatically generated

A graph with a line and numbers

Description automatically generated

(within response time)

A graph with a line

Description automatically generated

A graph of a graph

Description automatically generated with medium confidence

A graph with a red line

Description automatically generated

A graph with a green line

Description automatically generated

A graph with a line

Description automatically generated

## MTPA Control: Sinusoidal

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.73 |
| Power Extracted (Pbat) | 49.65 |
| Average Torque | 191.1 |
| SS Trq Ripple | 0 |
| U Control Load | 0.003717 |
| Current THD | 12.51 |
| Torque Tracking Error | 11.74 |

A screenshot of a computer program

Description automatically generated

A screen shot of a graph

Description automatically generated

A graph with numbers and lines

Description automatically generated

A graph showing a waveform

Description automatically generated with medium confidence

A graph with a red and blue line

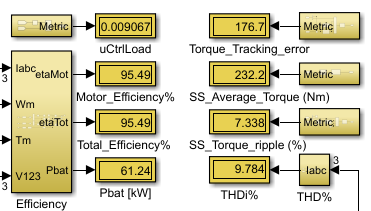
Description automatically generated

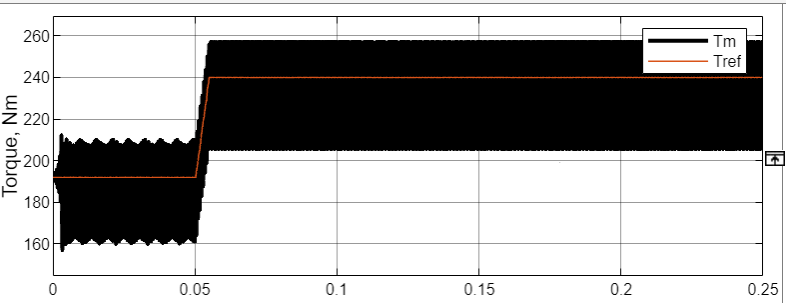
A graph showing a blue and green line

Description automatically generated

## MPC Control: Positive Gain / Step Change

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.49 |
| Power Extracted (Pbat) | 61.24 |
| Average Torque | 232.2 |
| SS Trq Ripple | 7.338 |
| U Control Load | 0.009067 |
| Current THD | 9.784 |
| Torque Tracking Error | 176.7 |





A close-up of a screen

Description automatically generated

A graph with a red and blue rectangle

Description automatically generated

A red and blue line

Description automatically generated

## MPC Control: Positive Gain / Sinusoidal

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.79 |
| Power Extracted (Pbat) | 46.77 |
| Average Torque | 180.1 |
| SS Trq Ripple | 0 |
| U Control Load | 0.008738 |
| Current THD | 20.78 |
| Torque Tracking Error | 22.22 |

A diagram of a machine

Description automatically generated with medium confidence

A black and orange wire

Description automatically generated

A graph of black and orange lines

Description automatically generated

A screen shot of a sound wave

Description automatically generated

A graph with blue and orange lines

Description automatically generated

A screen shot of a graph

Description automatically generated

## MPC Control: Negative Gain / Step Change

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.39 |
| Power Extracted (Pbat) | 63.19 |
| Average Torque | 239.9 |
| SS Trq Ripple | 0.02619 |
| U Control Load | 0.006978 |
| Current THD | 0.03741 |
| Torque Tracking Error | 0.02078 |

A screenshot of a computer

Description automatically generated

A graph with a line

Description automatically generated

A screen shot of a graph

Description automatically generated

A graph with a line

Description automatically generated

A graph with a red line

Description automatically generated

A close-up of a graph

Description automatically generated

A graph with a line and numbers

Description automatically generated with medium confidence

A graph with a red line

Description automatically generated

A graph with a line

Description automatically generated

## MPC Control: Sinusoidal / Negative Gain

Deadbeat sinusoidal ref, negative gain

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.76 |
| Power Extracted (Pbat) | 49.7 |
| Average Torque | 191.2 |
| SS Trq Ripple | 0 |
| U Control Load | 0.005472 |
| Current THD | 15361 |
| Torque Tracking Error | 11.34 |

A diagram of a number of numbers

Description automatically generated with medium confidence

A graph of a graph showing a number of objects

Description automatically generated with medium confidence

A graph with numbers and lines

Description automatically generated

A graph of a graph with a number of blue and orange lines

Description automatically generated with medium confidence

A colorful lines on a white background

Description automatically generated

A graph with red and blue lines

Description automatically generated

A graph showing a wave

Description automatically generated

A graph showing a wave

Description automatically generated

A graph with red and purple lines

Description automatically generated

## VSI: 10khz / Step Change

VSI part 1, step change, 10khz

|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.38 |
| Total Efficiency | 91.6 |
| Power Extracted (Pbat) | 51.56 |
| Average Torque | 192 |
| SS Trq Ripple | 0.004078 |
| U Control Load | 0.00471 |
| Current THD | 0.05156 |
| Torque Tracking Error | 0.0136 |

A diagram of a graph

Description automatically generated with medium confidence

A graph with a line in the middle

Description automatically generated

A graph with a red line

Description automatically generated

A graph with red line and blue line

Description automatically generated

A graph of a bar graph

Description automatically generated with medium confidencew

A yellow rectangular object with black lines

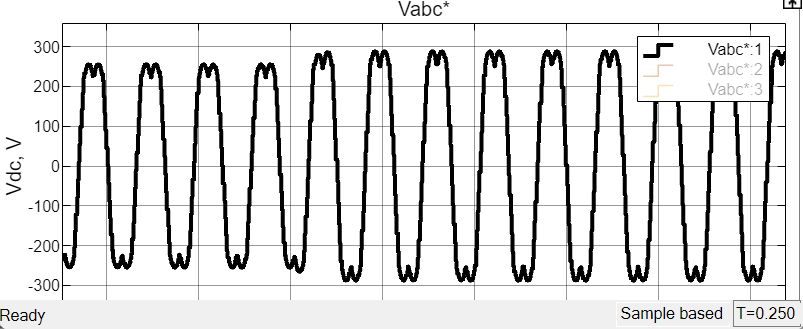
Description automatically generated

A close-up of a graph

Description automatically generated

A graph of a graph of a number of matches

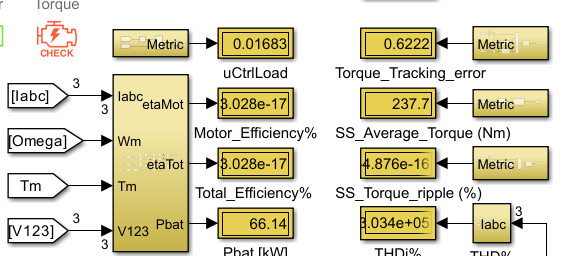
Description automatically generated with medium confidence

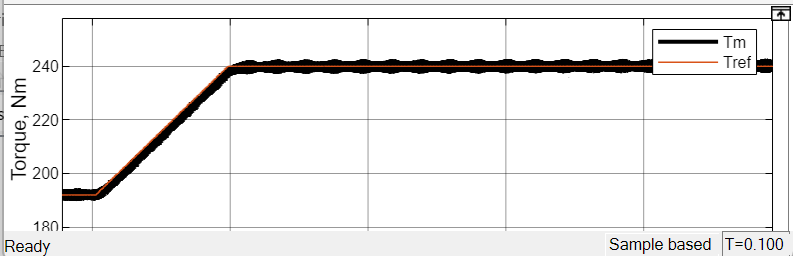
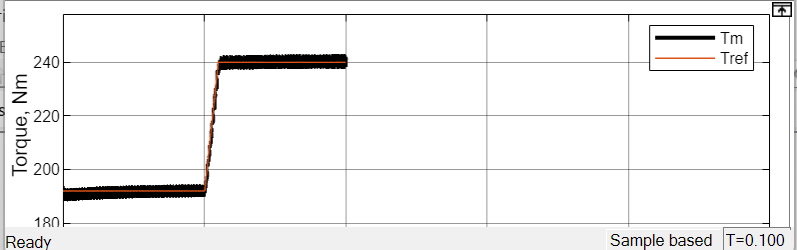


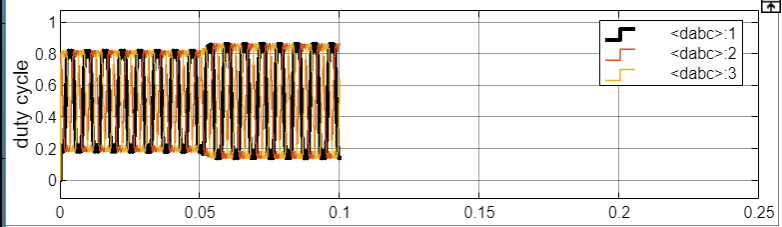
## VSI: 5KHz / Step Change

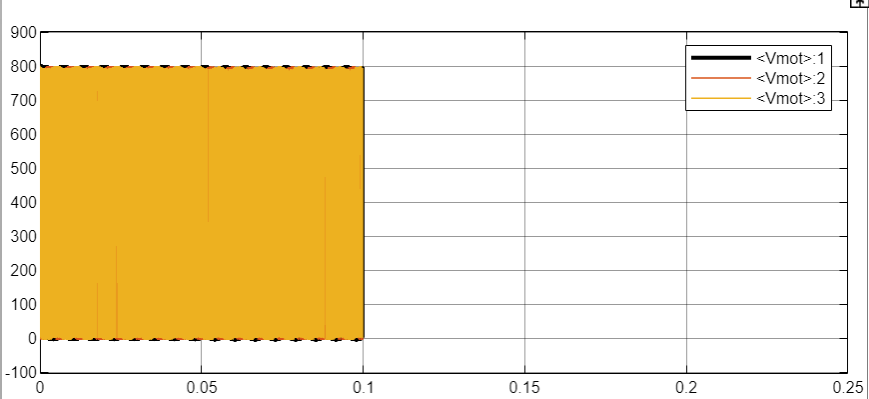
5khz: \*simulation fails at 0.1 sec\*

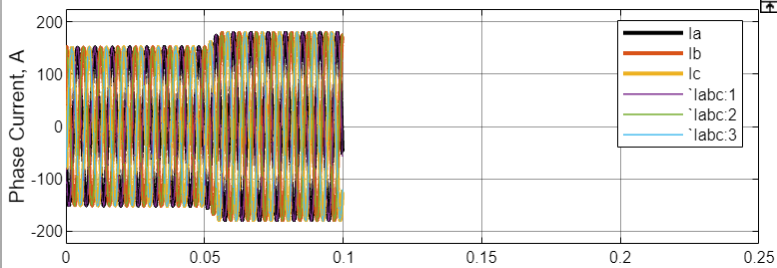
|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.38 |
| Total Efficiency | 91.6 |
| Power Extracted (Pbat) | 51.56 |
| Average Torque | 192 |
| SS Trq Ripple | 0.004078 |
| U Control Load | 0.00471 |
| Current THD | 0.05156 |
| Torque Tracking Error | 0.0136 |

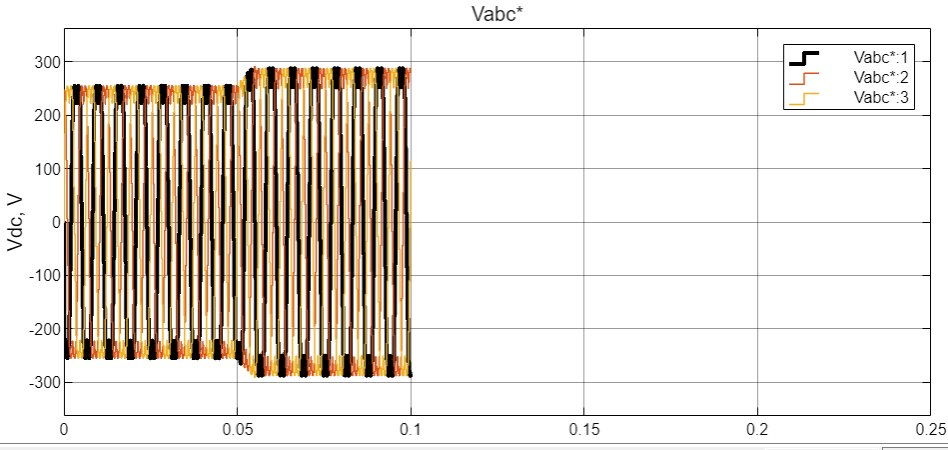


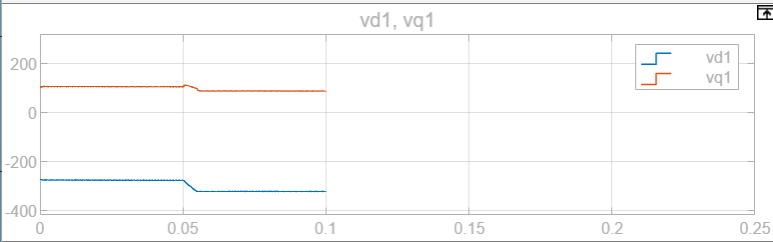
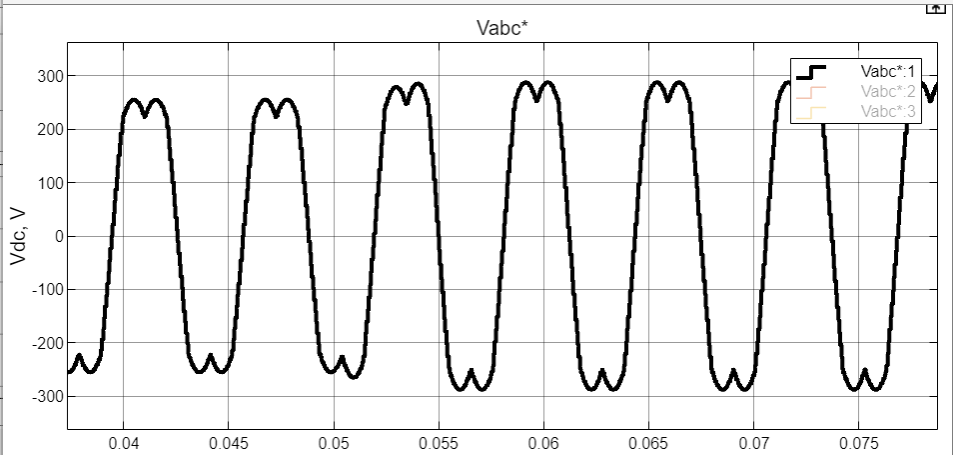


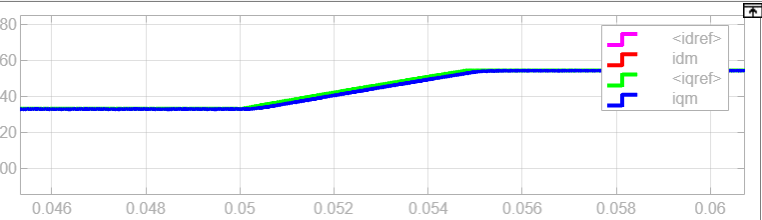








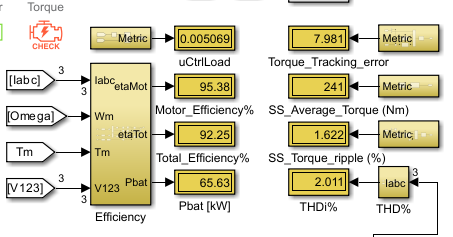


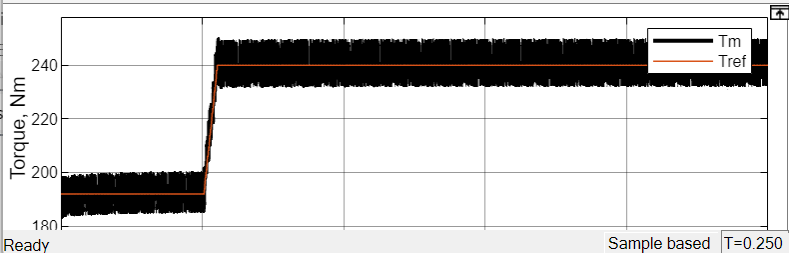


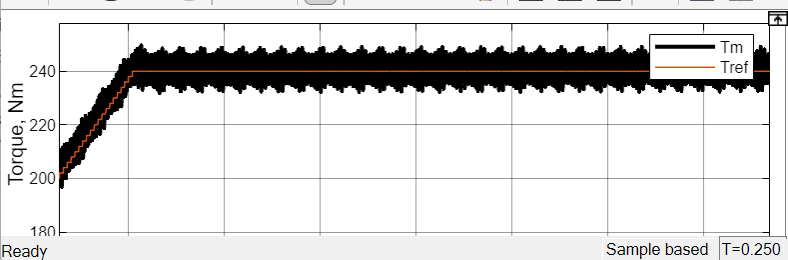
## VSI: 20KHz / Step Change

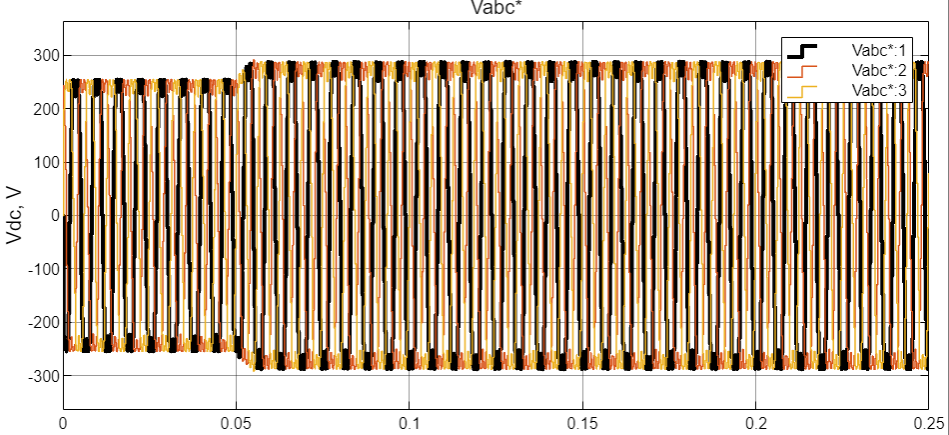
20khz:

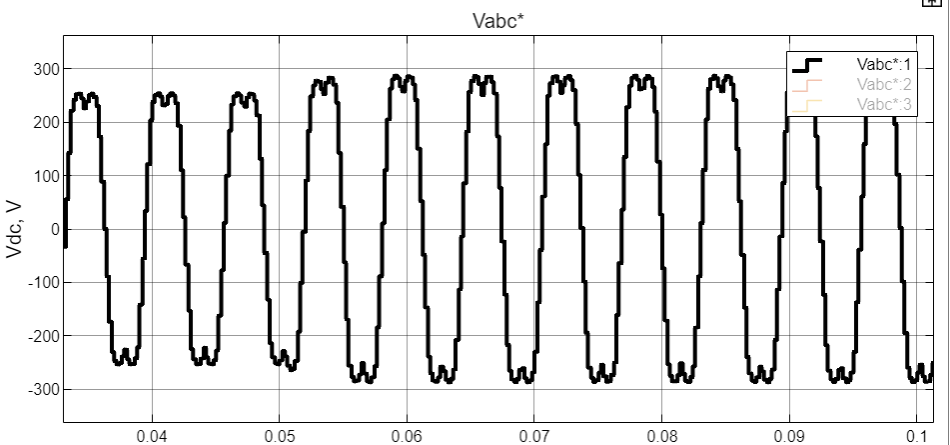
|  |  |
| --- | --- |
| Motor Efficiency (%) | 95.38 |
| Total Efficiency | 92.25 |
| Power Extracted (Pbat) | 65.63 |
| Average Torque | 241 |
| SS Trq Ripple | 1.622 |
| U Control Load | 0.005069 |
| Current THD | 2.011 |
| Torque Tracking Error | 7.981 |

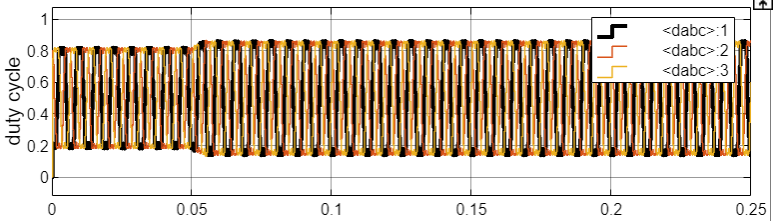


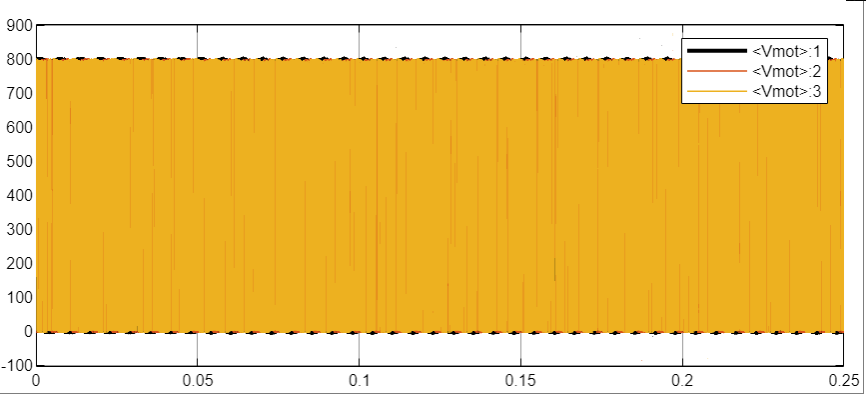


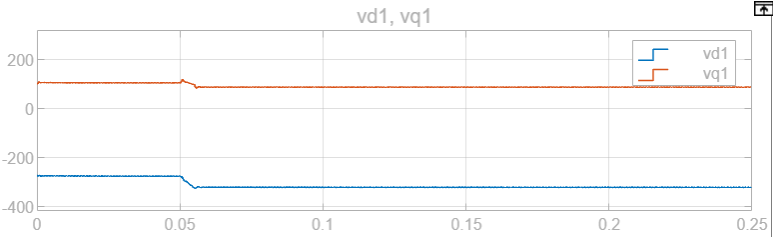


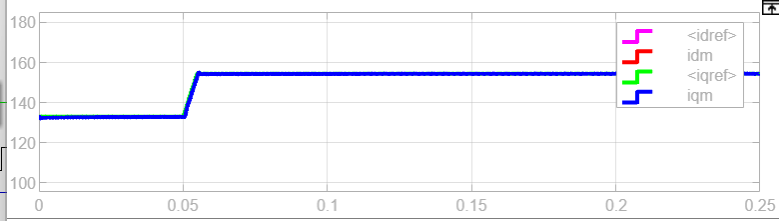




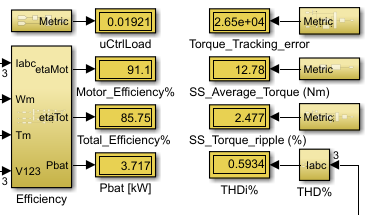


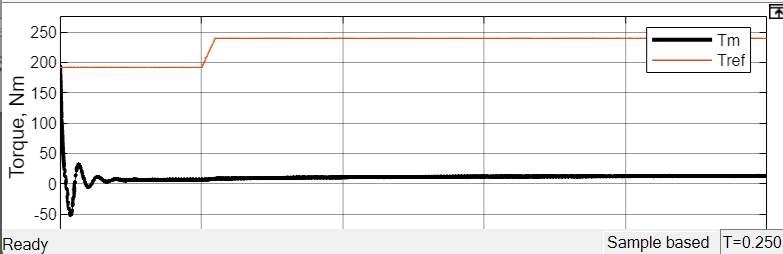


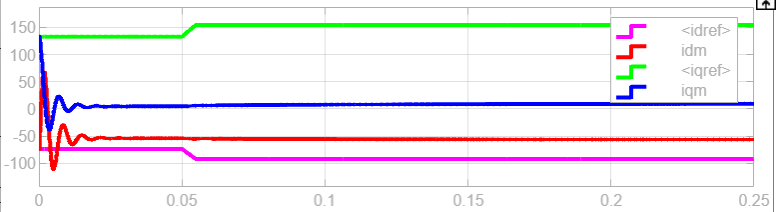


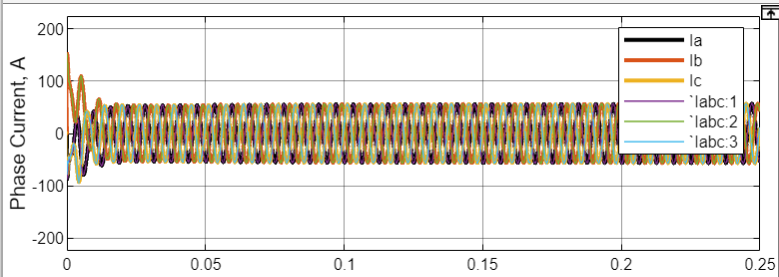


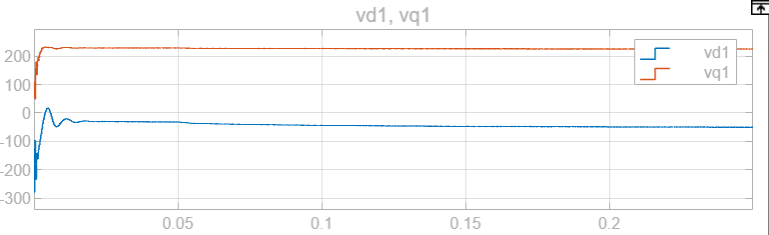
## VSI: 10KHz / Step Change / VDC/2











# Conclusion: