Electric Drive Laboratory Report

DC machine

Baraghini Nicholas 0000825055

University of Bologna
Automation Engineering Bachelor degree course

Contents

Chapter 1

Block Diagram of the overall Electric Drive

1.1 Parameters

```
%MOTOR parameters
RatedVoltage=48;
NoLoadSpeed=1420*(2*pi/60);
NoLoadCurrent=7.77e-3;
RatedSpeed=774*(2*pi/60);
RatedTorque=188e-3;
RatedCurrent=0.593;
StallTorque=415e-3;
StartingCurrent=1.29;
Resistance=37.10;
Inductance=9.31e-3;
TorqueCONSTANT=0.321;
SpeedCONSTANT=29.8*(2*pi/60);
RotorInertia=120e-7;
ArmatureTimeConstant=(Inductance/Resistance);

TotalInertia=(RotorInertia+LoadInertia);

%REGULATORS PARAMETERS
Current_KP=26331;
Current_KI=0.00025;
Speed_KP=1.0;
Speed_KI=0.415;
```

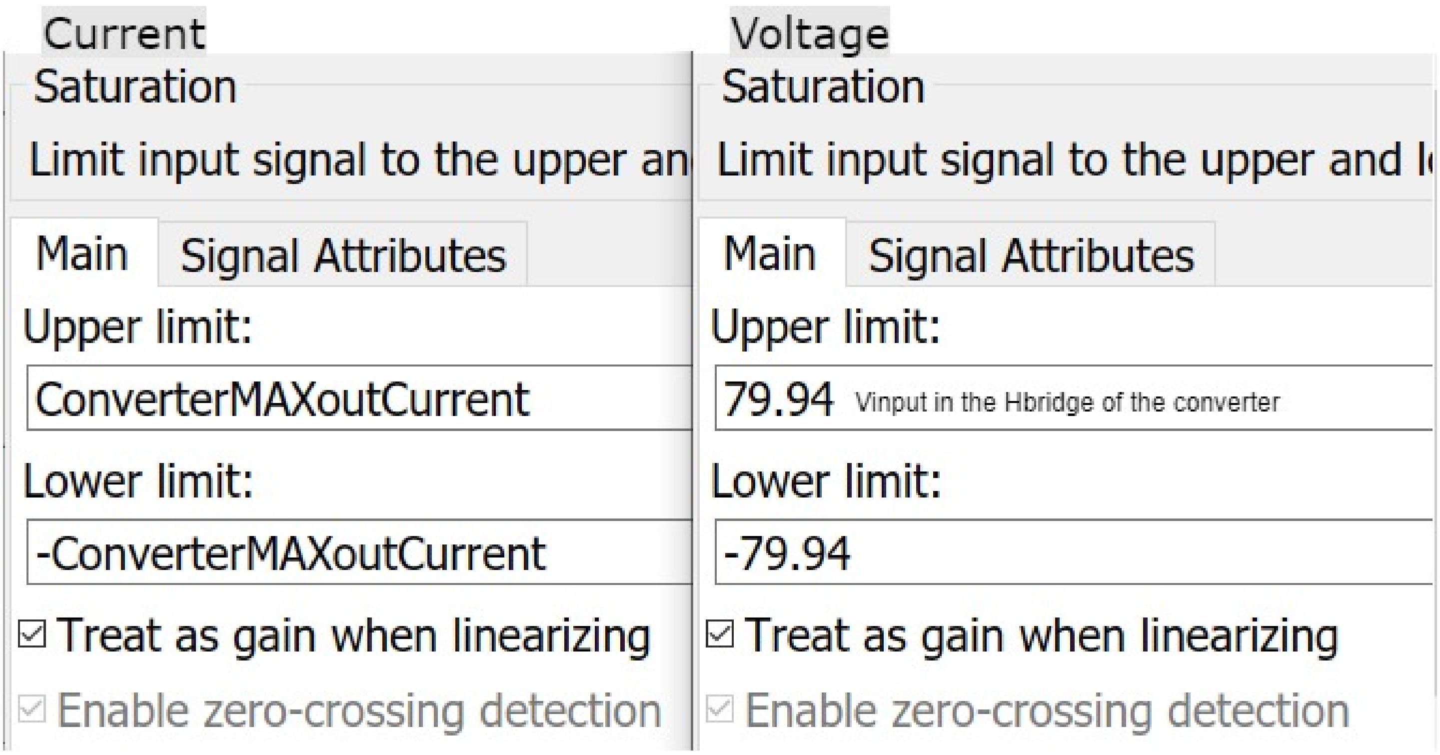
(a)

```
%SUPPLY SYSTEM (battery)
SupplyVoltage=80;
SupplyInternalResistance=0.4;
SupplyInternalInductance=0.4e-3;

%CONVERTER 4quadrantDC/DC
ConverterMAXoutCurrent=1.4;
CarrierFrequency=1e-5;
SampleTime=1e-8;

%CAPACITANCE  ( ALC10S1104DL )
Capacitance=10e-3;

%DIODE (CRS20I40A)
DiodeResistance=286;
DiodeVfm=0.43;

%N-MOSFET (BSD316SN)
MosfetResistance=160e-3;


%LOAD with a torque proportional to the speed
LoadTorqueSlope=1.6e-3;
LoadInertia=160e-7;
```

(b)

Figure 1.1: Variables linked and used in the Electric Drive model

1.2 Current and Voltage Saturation



1.3 Block Diagrams

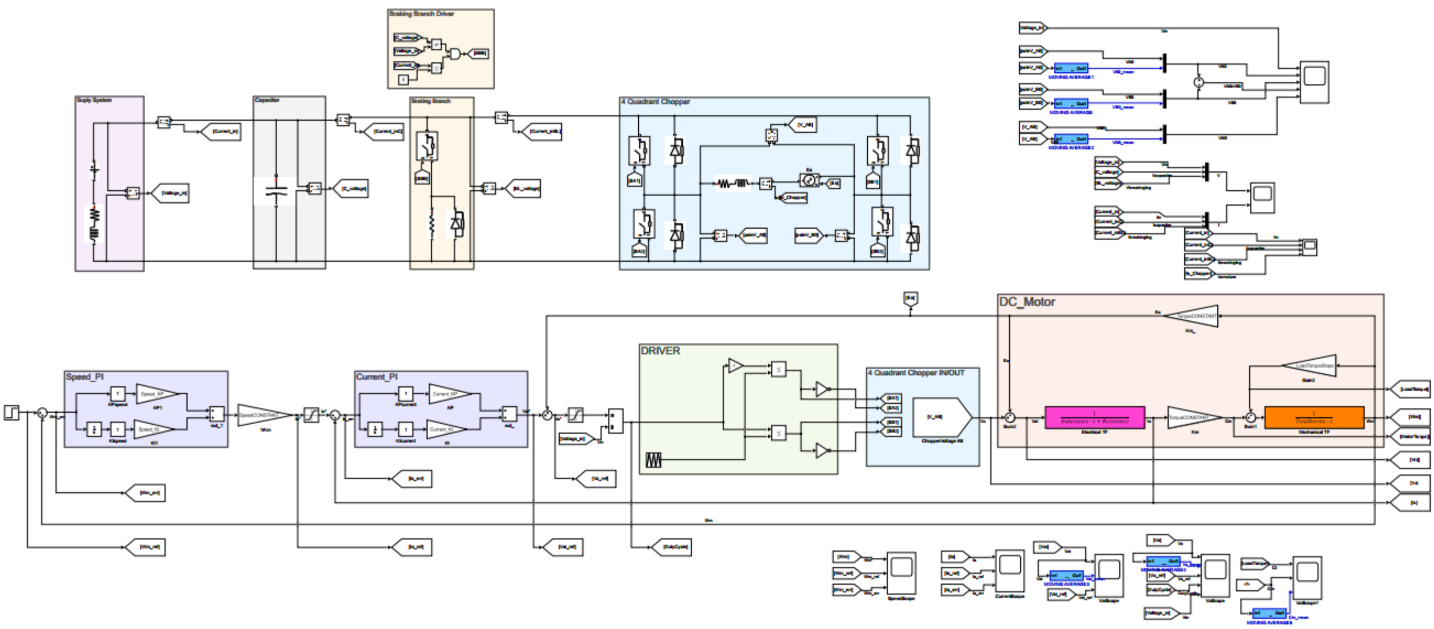


Figure 1.2: Block Diagram of the Electric Drive

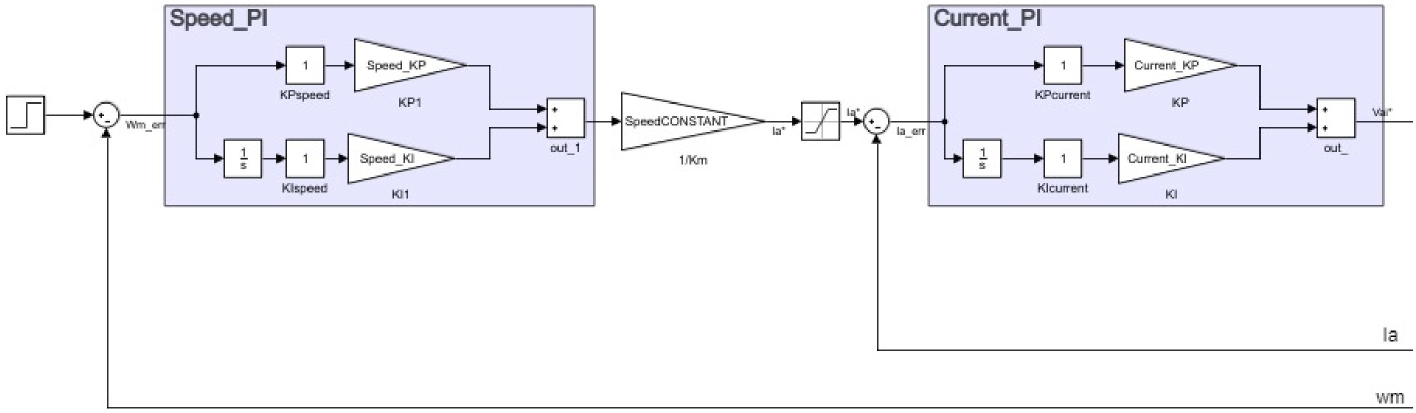


Figure 1.3: Detail of the PI controllers structure and the Input block

The two PI regulators have been tuned by using the PID tuning tool in the section "Tuning Methods" of the support program provided by MatLab, "rltool";The PID tuning tool allows to select the adjust the robustness and the settling time of the plant response.

It's applied as input a step which goes from 0rad/sec to 41rad/sec (50percent of the rated speed of 82rad/sec).

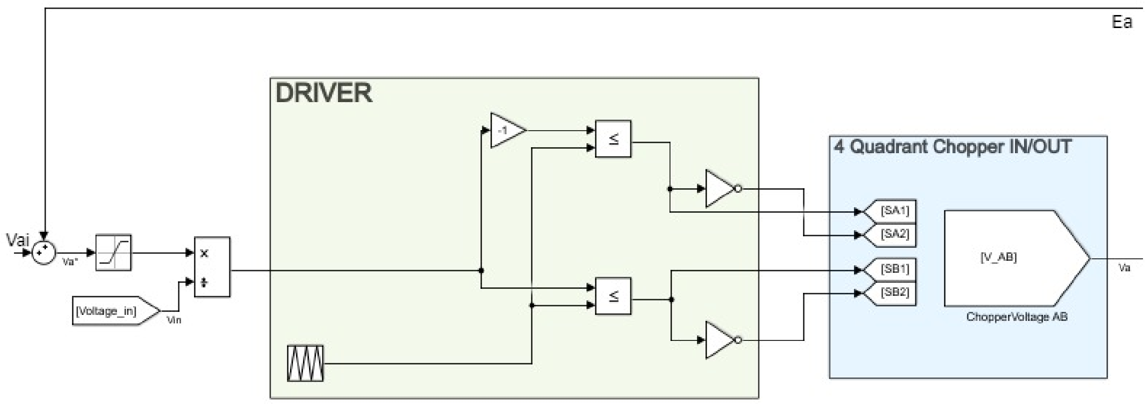


Figure 1.4: Detail of the Driver and the DC/DC chopper Input-Output

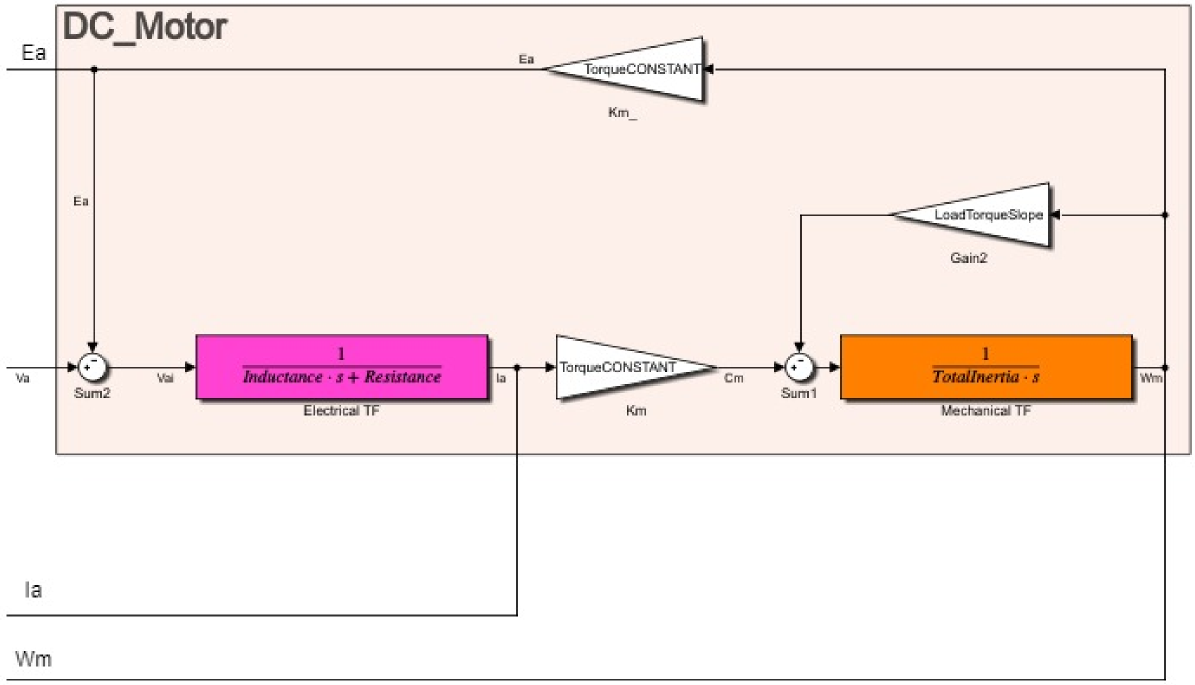


Figure 1.5: Detail of the DC motor

1.4 PI tuning adopted method

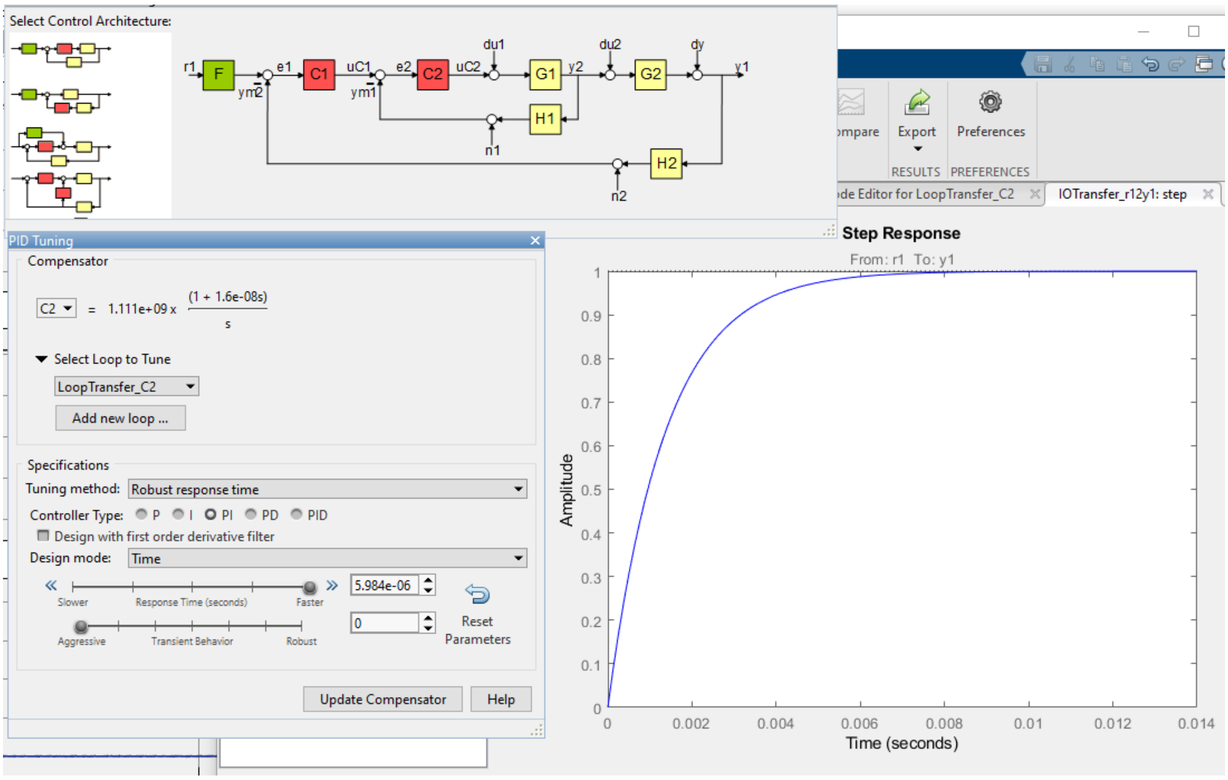


Figure 1.6: The image shows the rltool MatLab tool interface exploited to find the parameter of the two PI regulators (PI current reg. and PI speed reg.). In order to calculate the values of the coefficient related to the proportional and integral gain of the two PI controller it has been used the PID tuning tool inside the rltool interface which allows you to choose the correct parameter's values by tuning and selecting the rate of robustness and speed of the system and check if the requirements are met by looking the plotted simulated behaviour

Chapter 2

DC/DC chopper modelled with Simscape

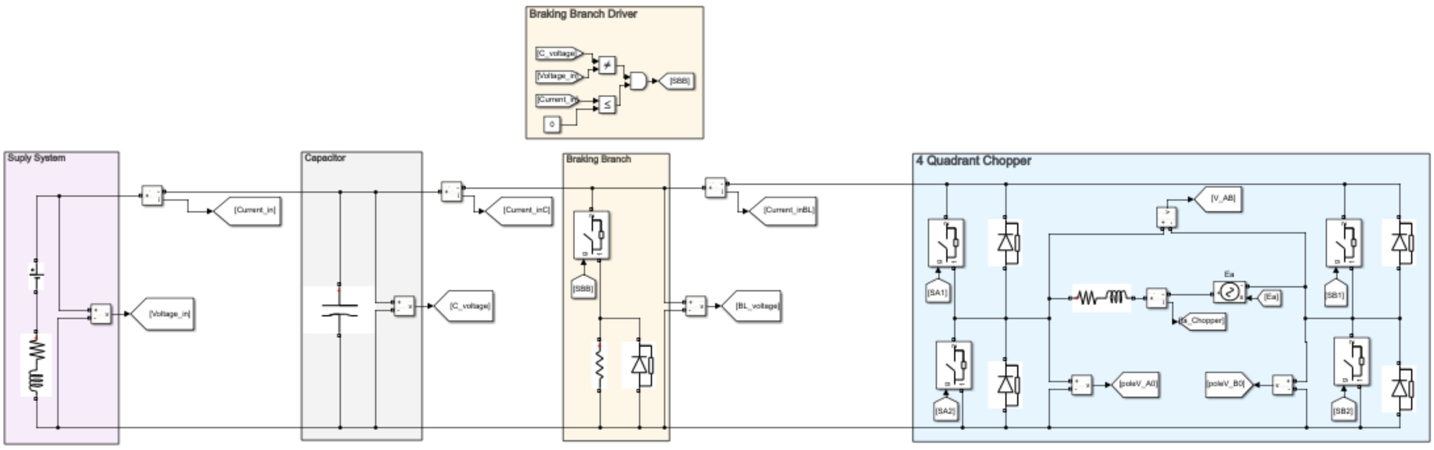


Figure 2.1: full diagram of the chopper

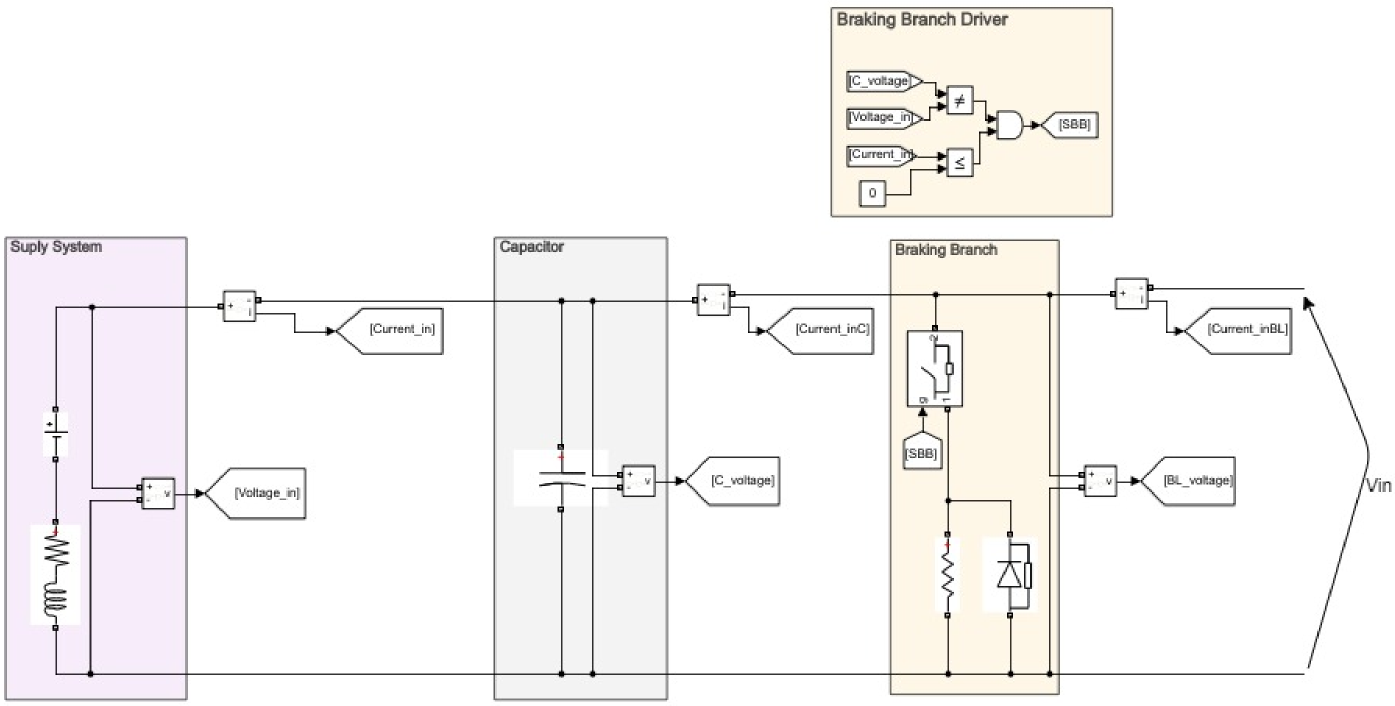


Figure 2.2: Source, capacitor and breaking leg

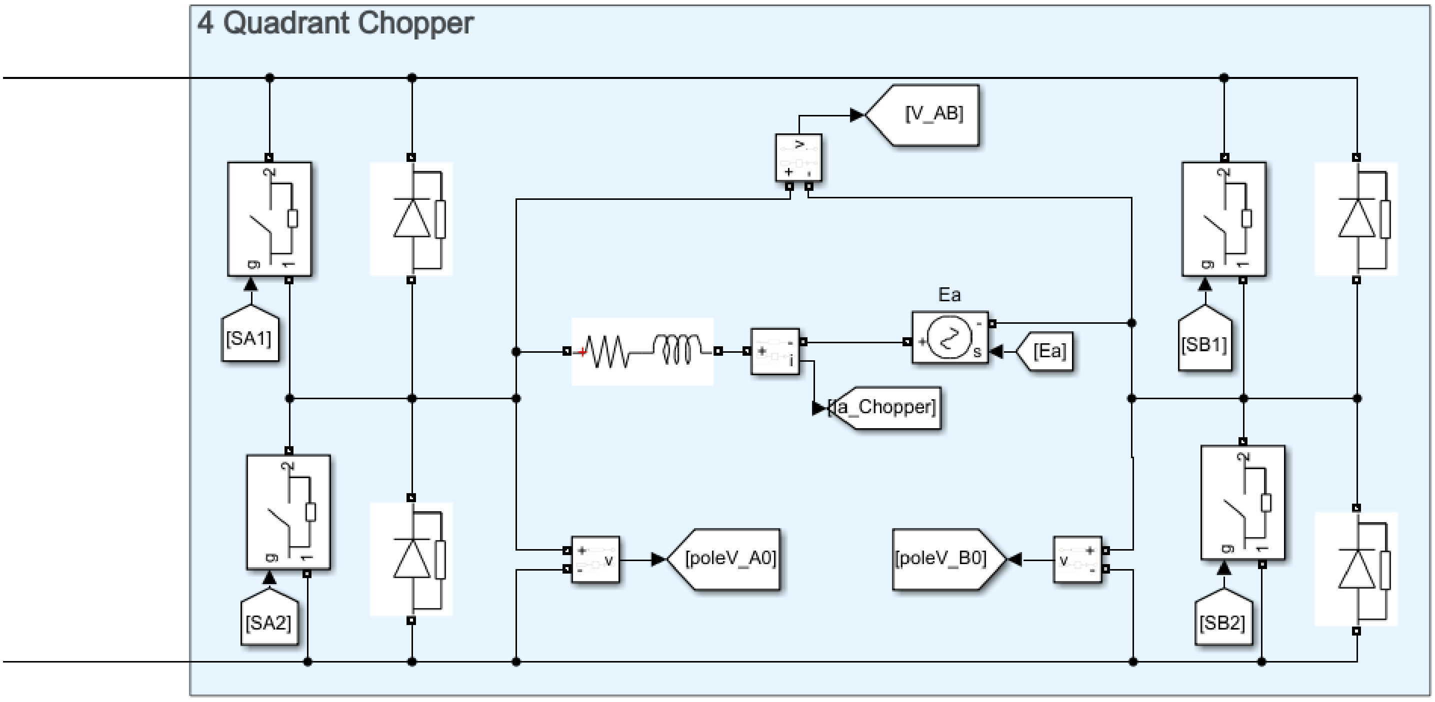


Figure 2.3: H-bridge

2.0.1 Voltage

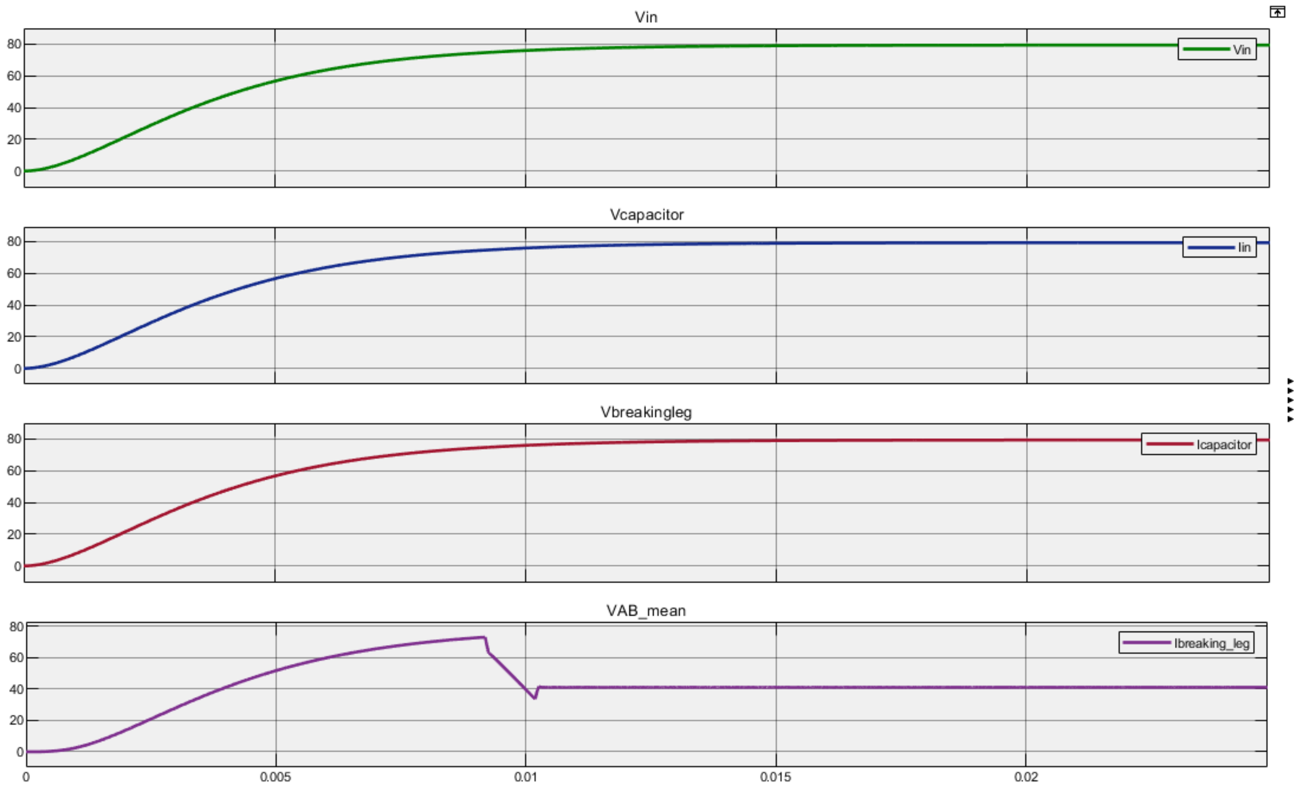


Figure 2.4: Voltage comparison between the various stages of the DC/DC chopper

2.0.2 Current

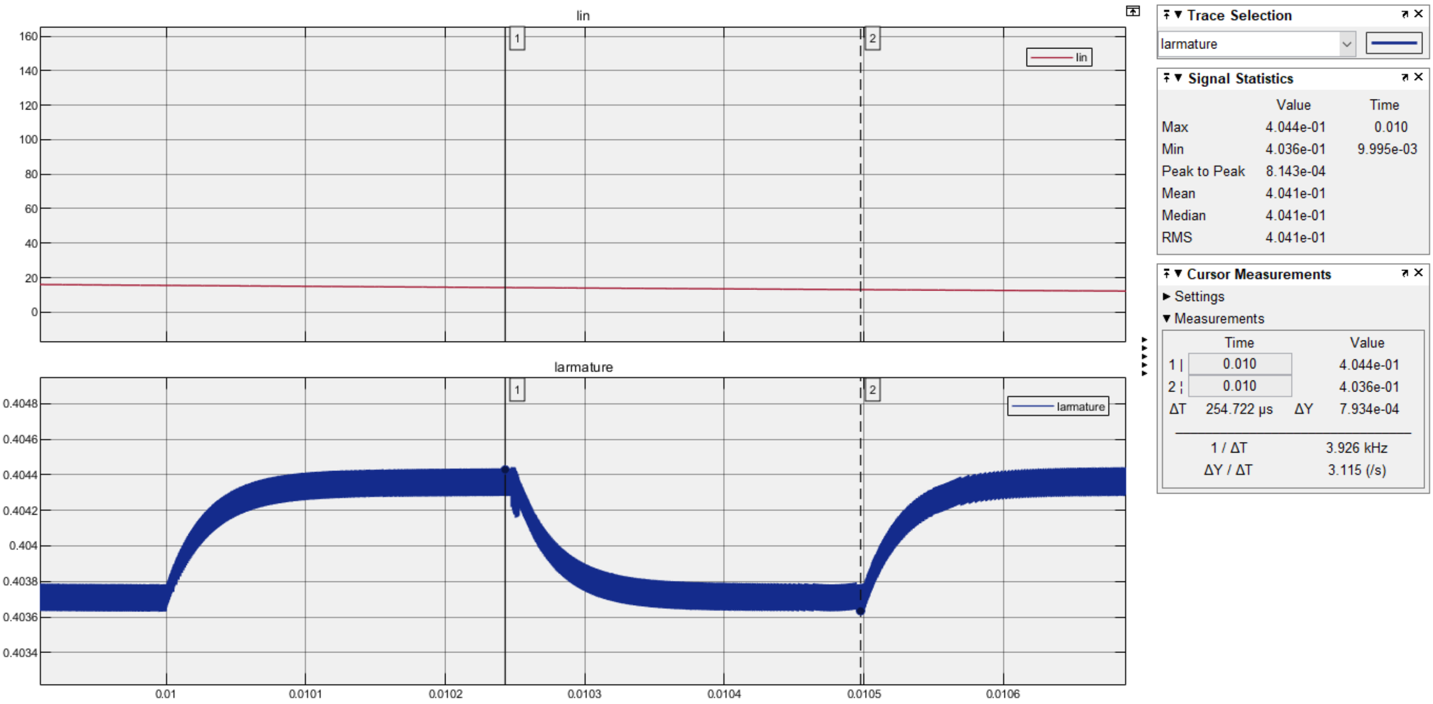


Figure 2.5: Current source compared with the current in the load of the quadrant chopper

The current ripple in the supply circuit is 0.0007934A for a carrier frequency of 1KHz. (which is less than the 1% of the average current source, or in other words, 0.004A)

2.1 Devices Used :

2.1.1 Capacitor

VDC	Rated Capacitance (µF)	Case Size	Part Number
50	10,000	35 x 50	ALC10S1102DF
63	10,000	35 x 60	ALC10S1103DH
80	10,000	35 x 80	ALC10S1104DL
100	10,000	40 x 90	ALC10S11052EX

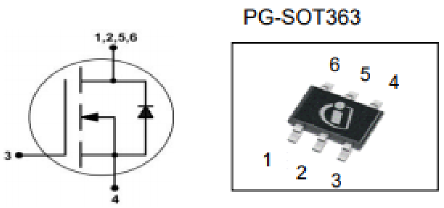
Figure 2.6: Detail of the capacitor data-sheet selected

2.1.2 N-MOSFET

BSD316SN

Product Summary

V_{DS}		30	V
$R_{DS(on),max}$	V_{GS}=10 V	160	mΩ
	V_{GS}=4.5 V	280	
I_D		1.4	A



(a)

Electrical characteristics, at T_j=25 °C, unless otherwise specified

Static characteristics

Drain-source breakdown voltage	$V_{(BR)DSS}$	V_{GS}=0 V, I_D=250 µA	30	-	-	V
Gate threshold voltage	$V_{GS(th)}$	V_{DS}=V_{GS} , I_D=3,7 µA	1.2	1.6	2.0	
Drain-source leakage current	I_{DSS}	V_{DS}=30 V, V_{GS}=0 V, T_j=25 °C	-	-	1	µA
		V_{DS}=30 V, V_{GS}=0 V, T_j=150 °C	-	-	100	
Gate-source leakage current	I_{GSS}	V_{GS}=20 V, V_{DS}=0 V	-	-	100	nA
Drain-source on-state resistance	$R_{DS(on)}$	V_{GS}=4.5 V, I_D=1.1 A	-	192	280	mΩ
		V_{GS}=10 V, I_D=1.4 A	-	120	160	
Transconductance	g_{fs}	$\|V_{DS}\|>2\|I_D\|R_{DS(on)max}$, I_D=1.1 A	-	2.3	-	S

(b)

Figure 2.7: Detail of the Mosfet Data-Sheet selected

2.1.3 Diode

TOSHIBA

Schottky Barrier Diode

CRS20I40A

1. Applications

- Secondary Rectification in Switching Regulators
- Reverse-Current Protection in Mobile Devices

2. Features

(1) Peak forward voltage: V_{FM} = 0.6 V (max) @I_{FM} = 2 A
(2) Average forward current: $I_{F(AV)}$ = 2 A
(3) Repetitive peak reverse voltage: V_{RRM} = 40 V
(4) Small, thin package suitable for high-density board assembly
Toshiba Nickname: S-FLAT™

(a)

Electrical Characteristics (Unless otherwise specified, T_a = 25 °C)

Characteristics	Symbol	Note	Test Condition	Min	Typ.	Max	Unit
Peak forward voltage	$V_{FM(1)}$		I_{FM} = 0.1 A (pulse measurement)	—	0.28	—	V
	$V_{FM(2)}$		I_{FM} = 1.0 A (pulse measurement)	—	0.42	—	
	$V_{FM(3)}$		I_{FM} = 2.0 A (pulse measurement)	—	0.53	0.60	
Repetitive peak reverse current	$I_{RRM(1)}$		V_{RRM} = 5 V (pulse measurement)	—	4	—	µA
	$I_{RRM(2)}$		V_{RRM} = 40 V (pulse measurement)	—	9	60	
Junction capacitance	C_j		V_R = 10 V, f = 1 MHz	—	35	—	pF

(b)

Figure 2.8: Detail of the Diode Data-Sheet selected

Chapter 3

Expected Performance

3.1 CURRENT:

3.1.1 Armature Current Scope

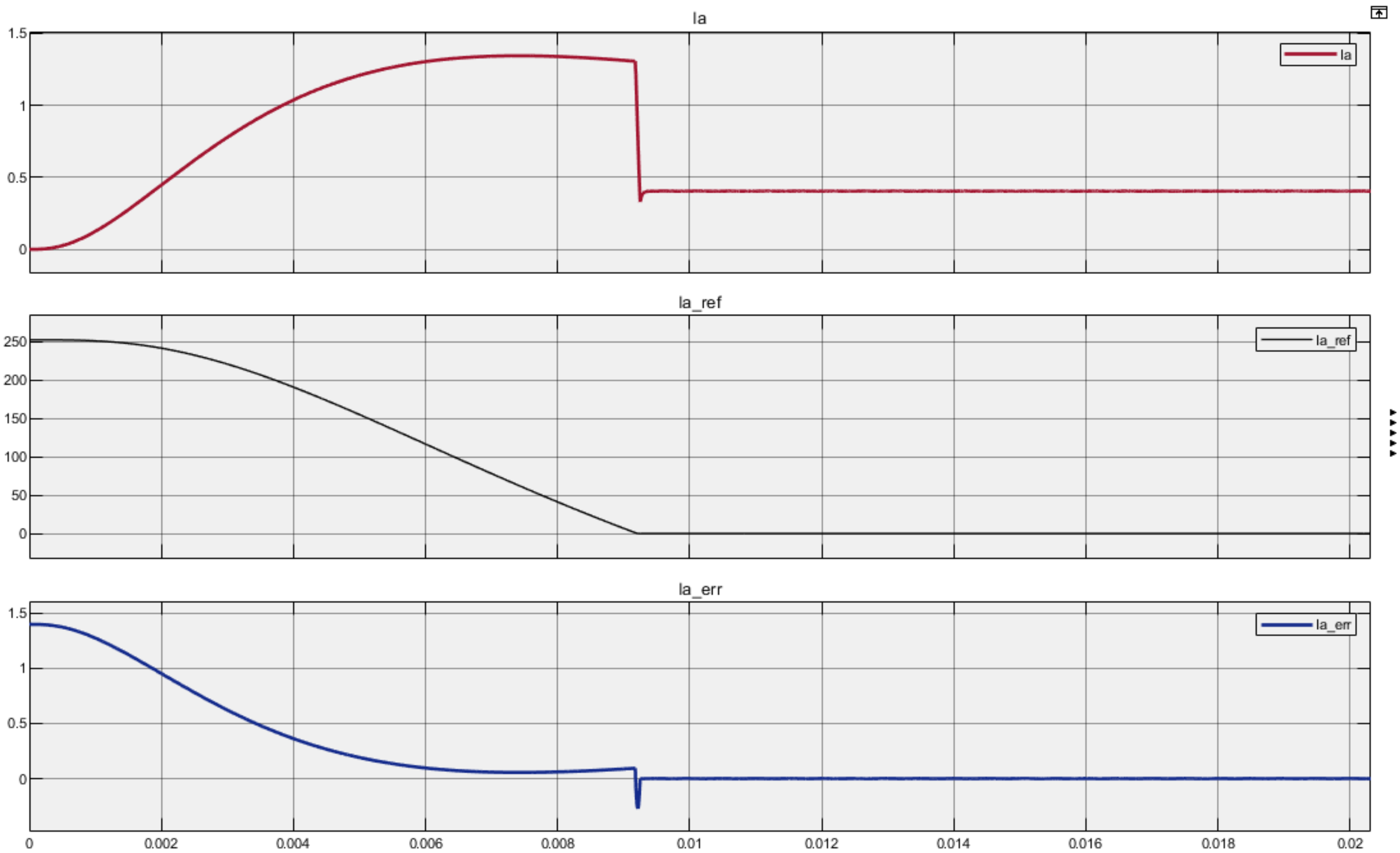


Figure 3.1: Armature current, Reference current and Current error of the current feedback

The armature current has a settling time of about 0.0095sec with a maximum value of 1.34A and a minimum of 0.335A applied a step variation from 0 to 81rad/sec on the speed reference;

3.1.2 Armature Current Ripple

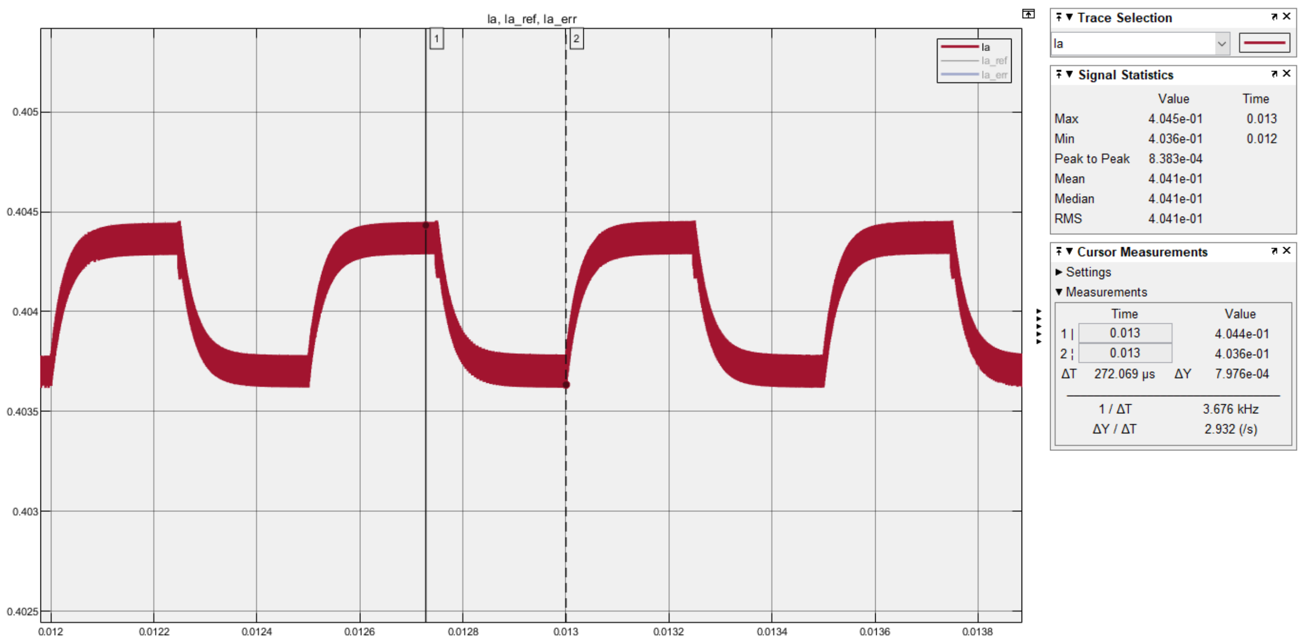


Figure 3.2: measurement of the current ripple

The ripple of the armature current is 0.0007976A for a carrier frequency of 1kHz; (which is less than the max current ripple allowed of 0.0593A)

3.2 SPEED :

3.2.1 Speed Scope

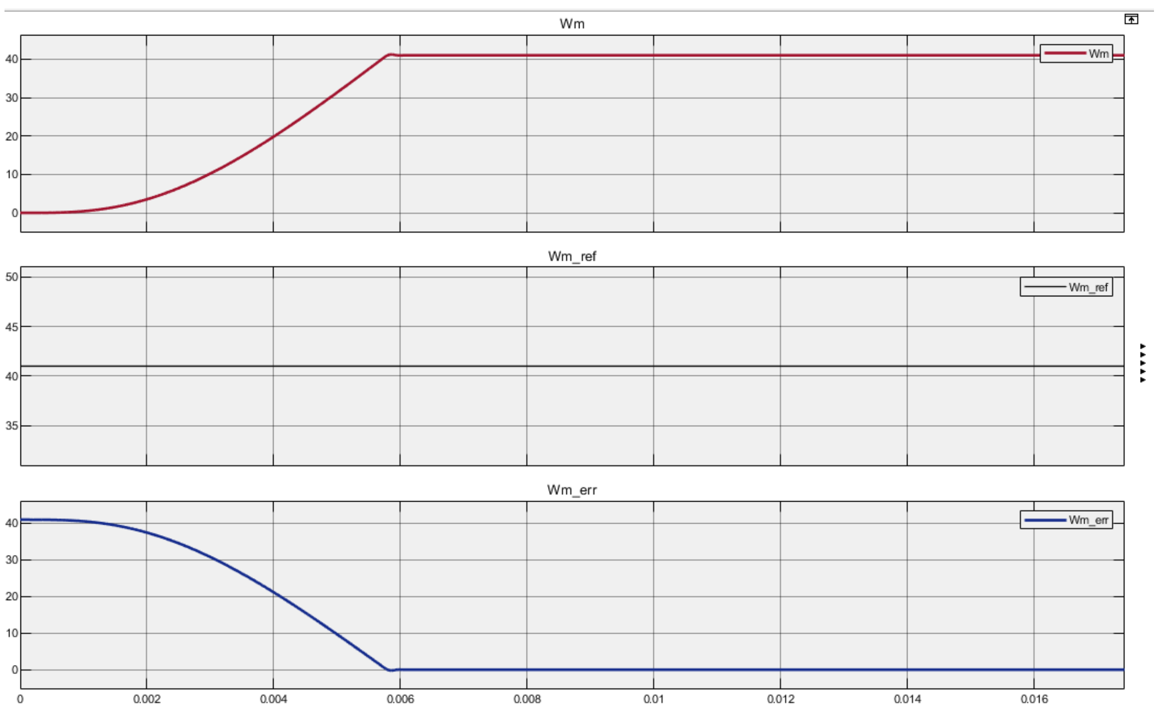


Figure 3.3: plot of the actual speed, the reference speed and the speed error

The speed reference is a step function which goes from 0 to 41rad/sec (50percent of the nominal speed of 81rad/sec).

3.2.2 Speed Overshoot

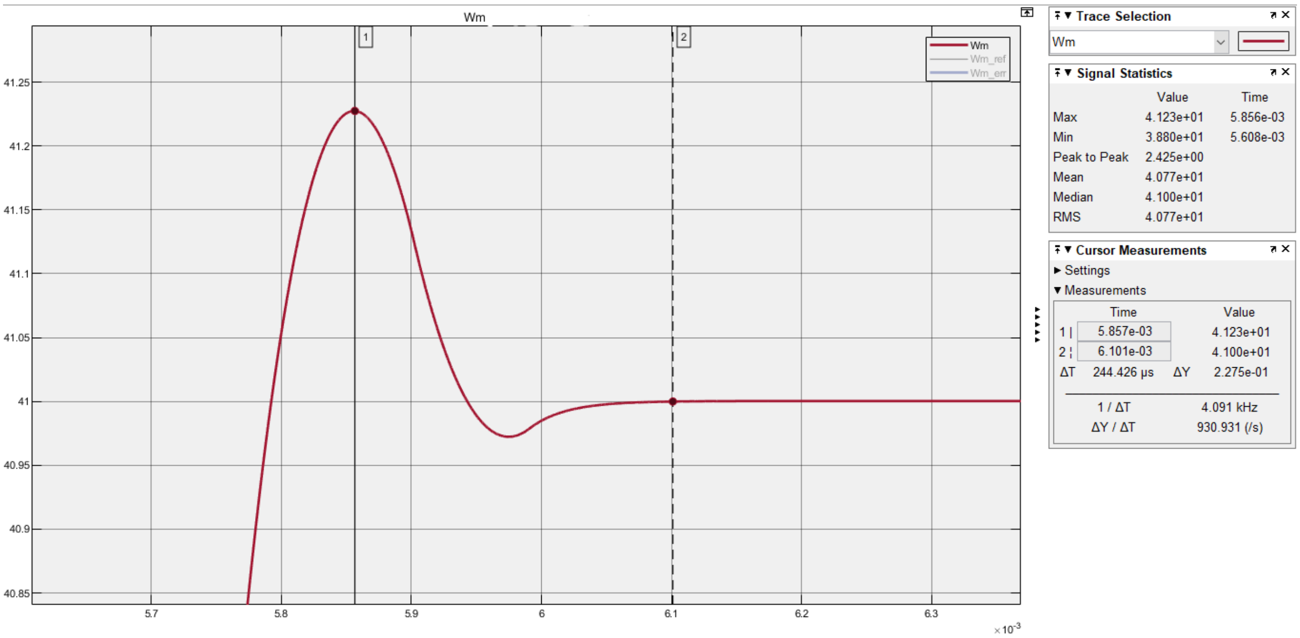


Figure 3.4: detail of the overshoot in the speed behaviour

The speed presents an overshoot, after 0.005857sec, of 0.2271 which is lower than the 1percent of the reference steady state value (0.41).

3.2.3 Steady State

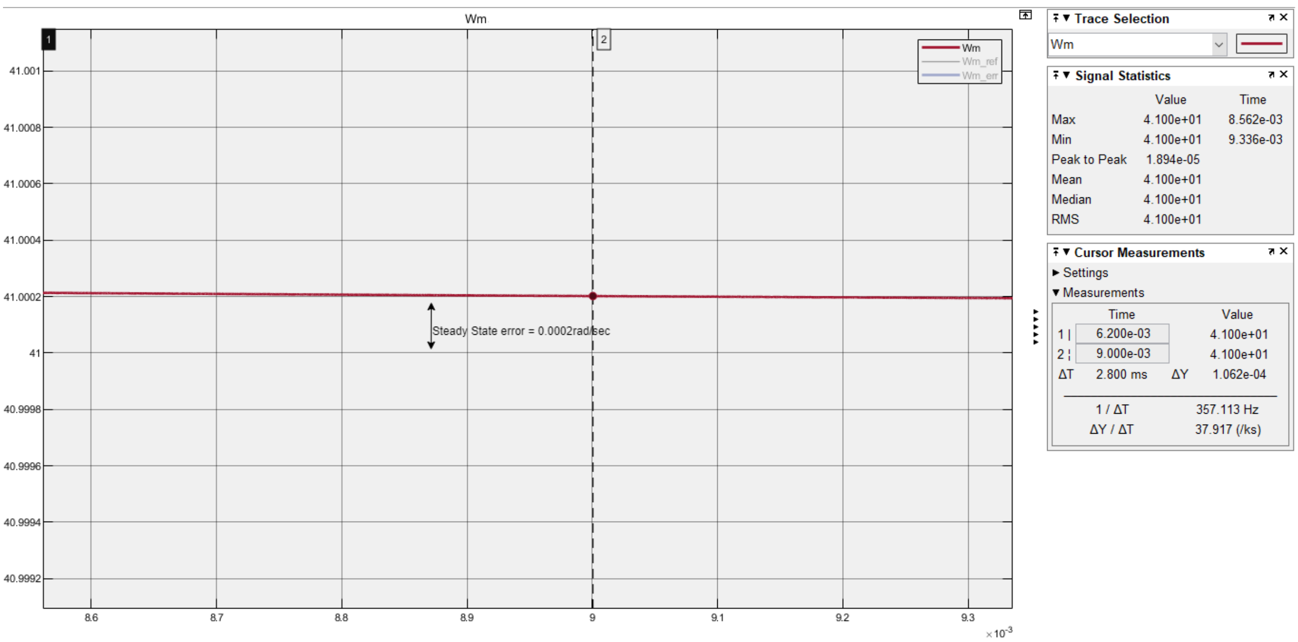


Figure 3.5: detail of the steady state behaviour of the speed characteristics

The speed has a settling time of 0.009sec with an error of 0.0002rad/sec with respect to the reference value of 41rad/sec (which is lower than the max. speed error allowed of 1% of the half-nominal speed or in other words 0.41rad/sec)