SIDANG TUGAS AKHIR

DESAIN KONTROL KECEPATAN MOTOR BRUSHLESS DC BERBASIS *POWER FACTOR CORRECTION* (PFC) MENGGUNAKAN *SINGLE ENDED PRIMARY INDUCTANCE CONVERTER* (SEPIC)

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Outline

Latar Belakang

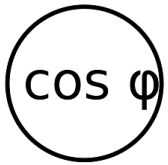
P. Yedamale (2003)

- Lifetime tinggi
- Respon dinamik baik
- Efisiensi tinggi
- Tidak ada percikan
- Range kecepatan tinggi

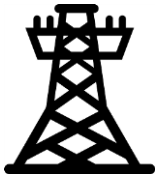
Pengaplikasian

- Pompa
- Blower
- Peralatan Medis

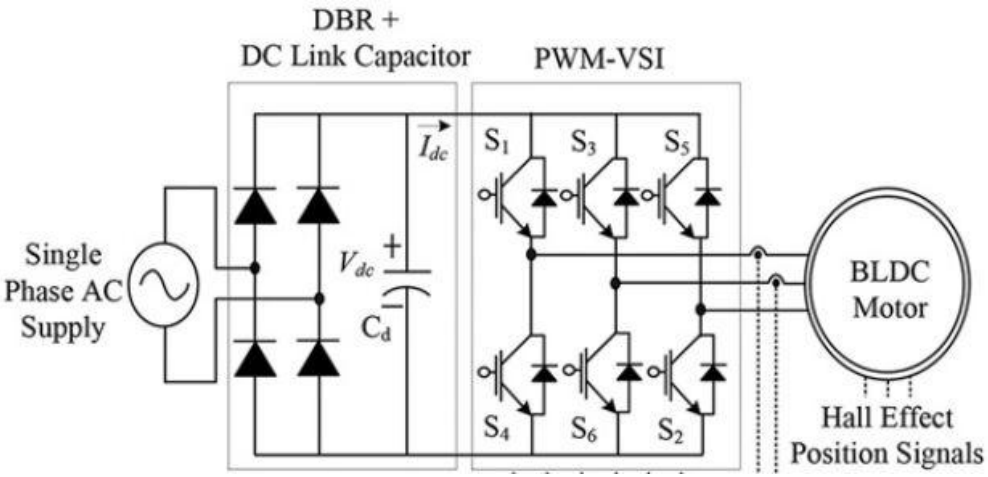
Latar Belakang



Rendahnya Faktor Daya



Tingginya Nilai THD Arus



PF	0.732
THD i	74.39%

Tujuan

1. Motor dapat dioperasikan pada tingkat kecepatan bervariasi
2. Motor dapat beroperasi pada tingkat pembebanan yang bervariasi
3. Memiliki PF dan THD yang memenuhi standar

Batasan Masalah

1. Sumber yang digunakan merupakan sumber AC 220 rms
2. Motor brushless DC yang digunakan adalah motor brushless DC tiga fasa pabrikan Moog
3. Penelitian ini membahas tentang desain dan analisis simulasi, tidak membahas tentang implementasi secara langsung
4. Nilai *Gain* (Kp) dan *Time constant* (Ki) didapatkan dengan metode *trial and error*

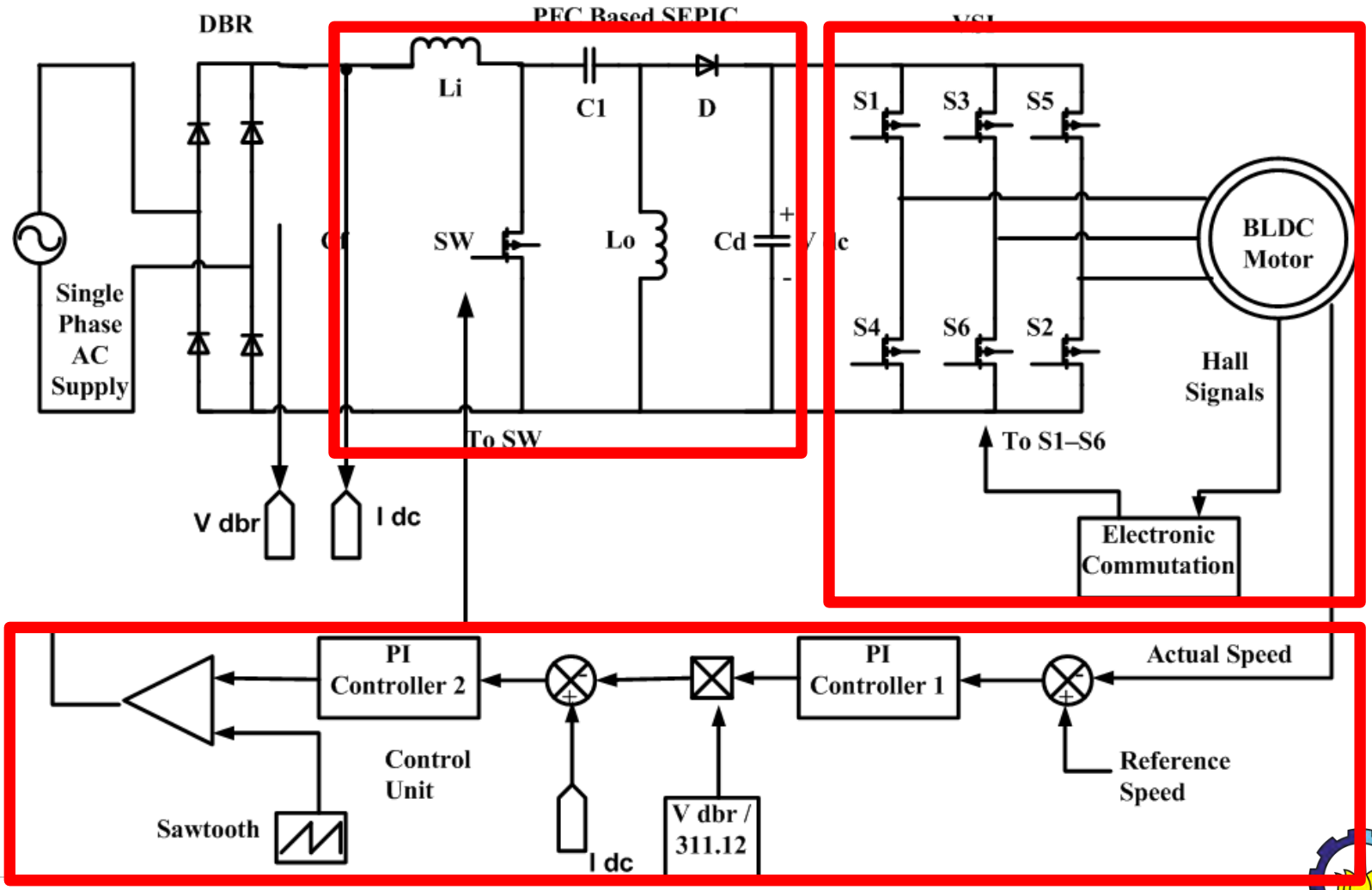
Desain Sistem Kontrol

Datasheet Motor

Parameter	Nilai
Panjang	134.6 millimeter
Tegangan Terminal	100 Volt
Torsi Maksimal	18.0744 Nm
Kecepatan Rating	2500 Rpm
Torsi Rating	2.9588 Nm
Arus Rating	10.2 Ampere
Daya Rating	874 Watt
Sensitivitas Torsi	0.3269 Nm/Ampere
Back EMF	34.2 Volts/krpm
Resistansi	0.408 Ohm
Induktansi	1.71 mH
Inersia Rotor	4939.9 gr-cm^2
Berat	5168.8 gr
Timing	120 Derajat
Mech. Time Constant	1.9 ms
Electrical Time Constan	4.19 ms

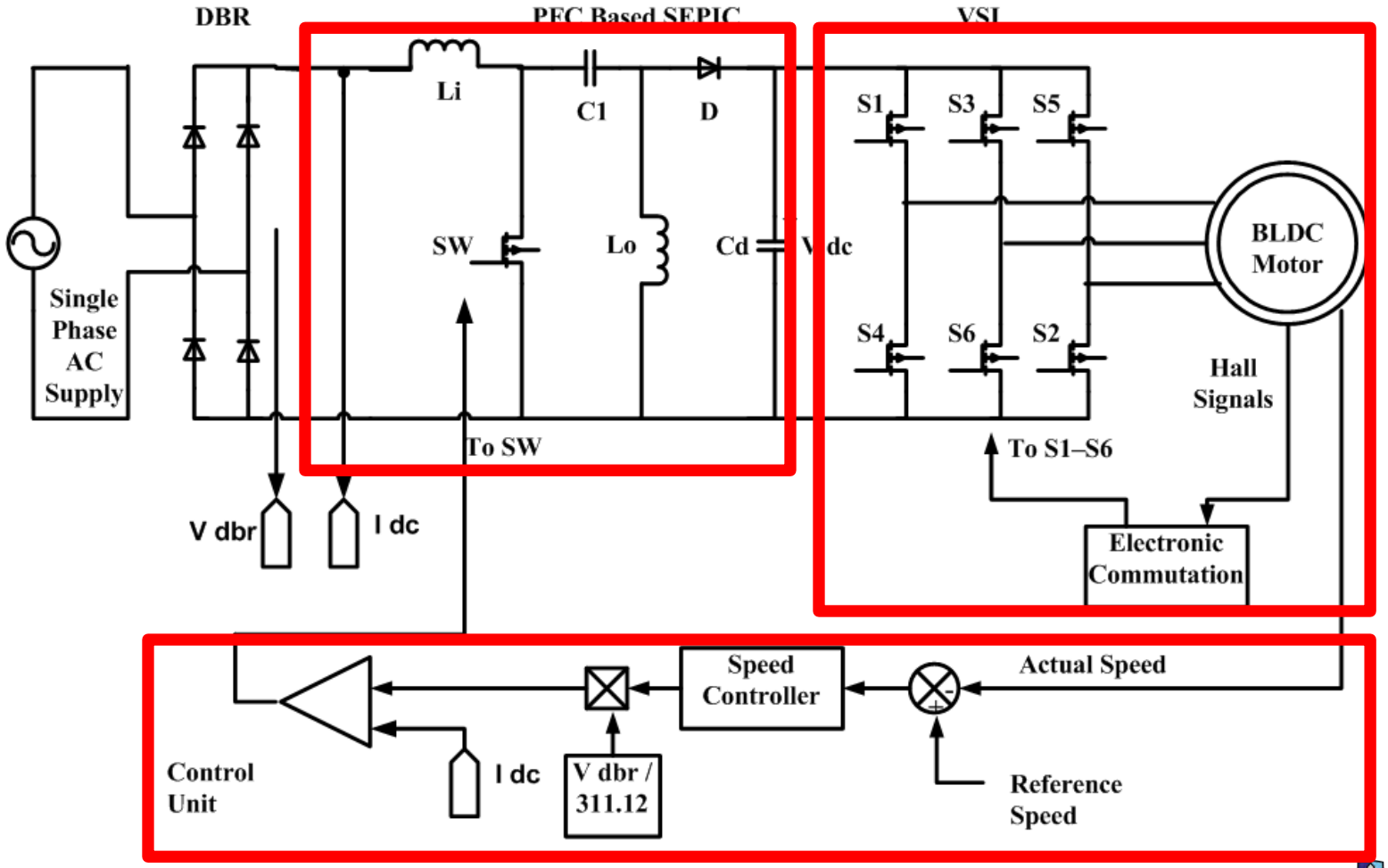
Desain Sistem Kontrol

Average Current Control



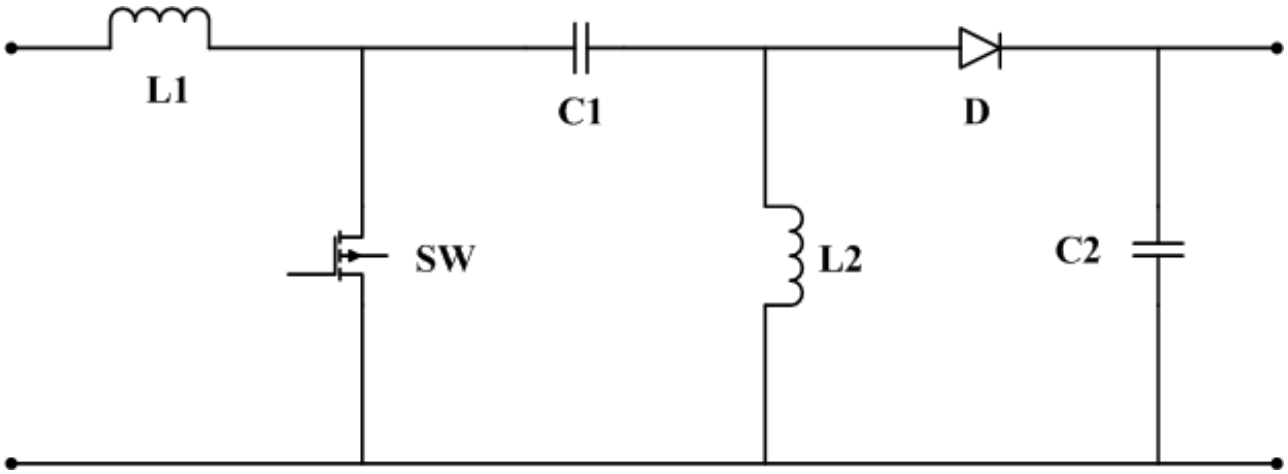
Desain Sistem Kontrol

Hysteresis Current Control



Desain Sistem Kontrol

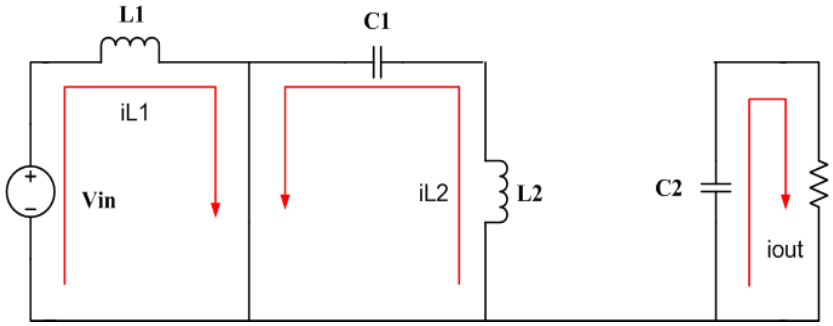
Konverter SEPIC

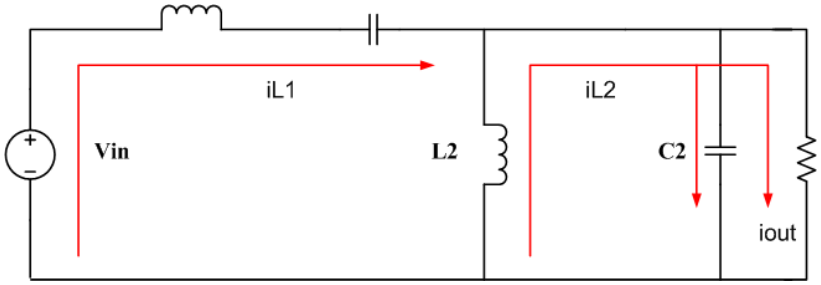


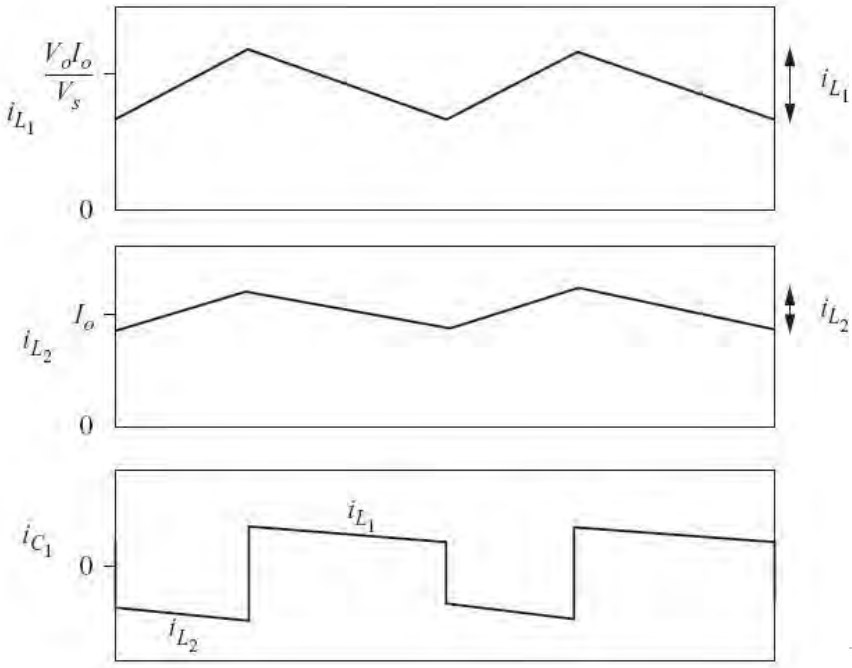
Vs	220 V	Speed max	2500 rpm	Pmax	874 W
Vo	100 V	Speed min	700 rpm	Pmin	262 W

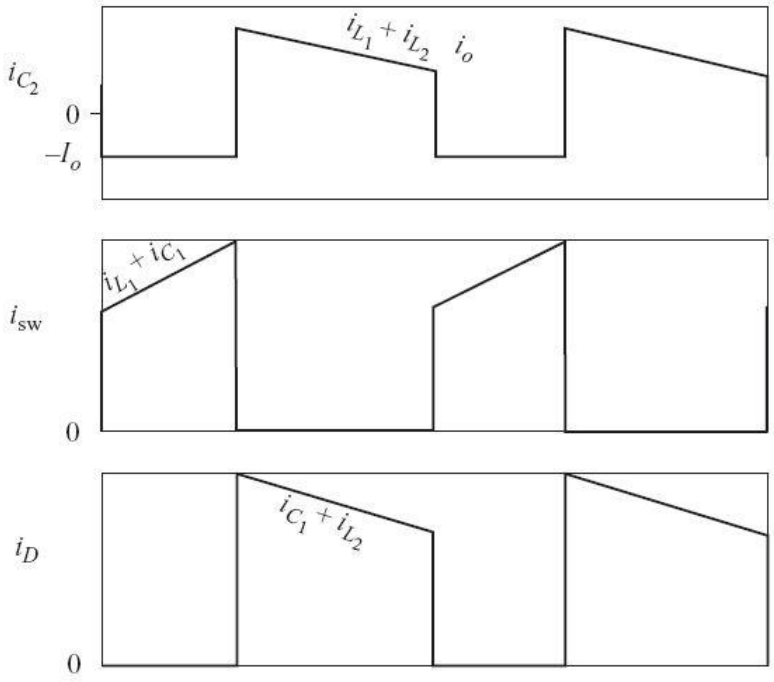
Desain Sistem Kontrol

Mekanisme SEPIC









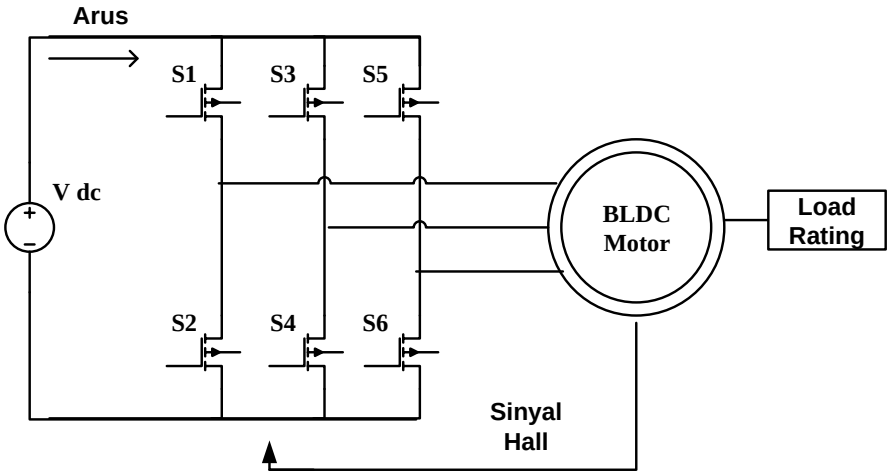
Desain Sistem Kontrol

Nilai Induktor Input

$$L_1 = \frac{V_{in}\ x\ D}{\Delta I_{L1}\ x\ f}$$

$$V_{in} = \frac{2\sqrt{2}\,Vs}{\pi} = \frac{2\sqrt{2}\ x\ 220}{\pi} = 198\,Volt$$

$$D_n = \frac{V_{dc\_link}}{V_{dc\_link} + V_{rec}} = \frac{100}{100 + 198} = 0.3355$$



$$I_{L1} = \frac{V_o x I_o}{V_{in}}$$

$$I_{L1} = \frac{100\ x\ 8.95}{198} = 4.52\ Ampere$$

$$\Delta I_{L1}\ (ripple\ 10\%) = \frac{10}{100}\ x\ 4.52 = 0.452\ Ampere$$

$$\Delta I_{L1}\ (ripple\ 10\%) = \frac{10}{100}\ x\ I_{L1}$$

$$L_1 = \frac{Vs\ x\ D}{\Delta I_{L1}\ x\ f} = \frac{198\ x\ 0.3355}{0.452\ x\ 20000} = \mathbf{7.35\ mH}$$

Desain Sistem Kontrol

Nilai Induktor Output (CCM)

$$L_2 = \frac{Vin\ x\ D}{\Delta I_{L2}\ x\ f}$$

$$\Delta I_{L2}\ (ripple\ 10\%) = \frac{10}{100}\ x\ I\ out$$

$$\Delta I_{L2}\ (ripple\ 10\%) = \frac{10}{100}\ x\ 8.95 = 0.895\ Ampere$$

$$L_2 = \frac{Vin\ x\ D}{\Delta I_{L2}\ x\ f} = \frac{198\ x\ 0.3355}{0.895\ x\ 20000} = \mathbf{3.71\ mH}$$

Nilai Induktor Output (DCM)

$$L_c = \frac{V_{in}^2}{P_{min}}\ x\ \frac{V_{dc\_min}}{2\sqrt{2}V_{in}f}\ x\ \frac{V_{dc\_min}}{\sqrt{2}V_{in} + V_{dc\_min}}$$

$$L_c = \frac{220^2}{262}\ x\ \frac{30}{2\sqrt{2}x220x20000}\ x\ \frac{30}{\sqrt{2}x220 + 30}$$

$$P_{min} = \frac{V_{dc\_min}}{V_{dc\_rating}} P_{rating}$$

$$P_{min} = \frac{30}{100}\ x\ 874 = 262\ Watt$$

$$L_c = 0.039\ mH$$

$$L_c = \frac{0.039\ mH}{3}$$

$$L_c = \mathbf{0.013\ mH}$$

Desain Sistem Kontrol

Nilai Kapasitor Intermediat

$$C_1 = \frac{P_{max}}{K\ x\ f_s\ x\ (\sqrt{2}\ V_{in} + V_{dc\_link})^2}$$

$$C_1 = \frac{874}{0.25\ x\ 20000\ x\ (\sqrt{2}\ x\ 220 + 100)^2}$$

$$C_1 = \mathbf{1.03\ \mu F}$$

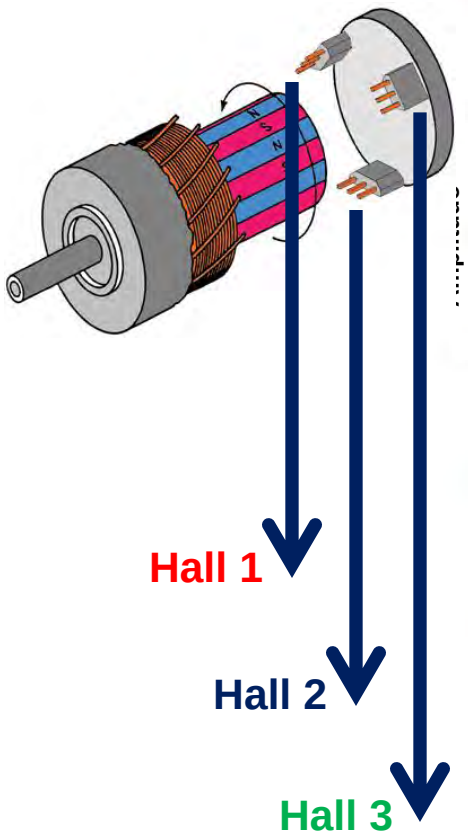
Nilai Kapasitor Output

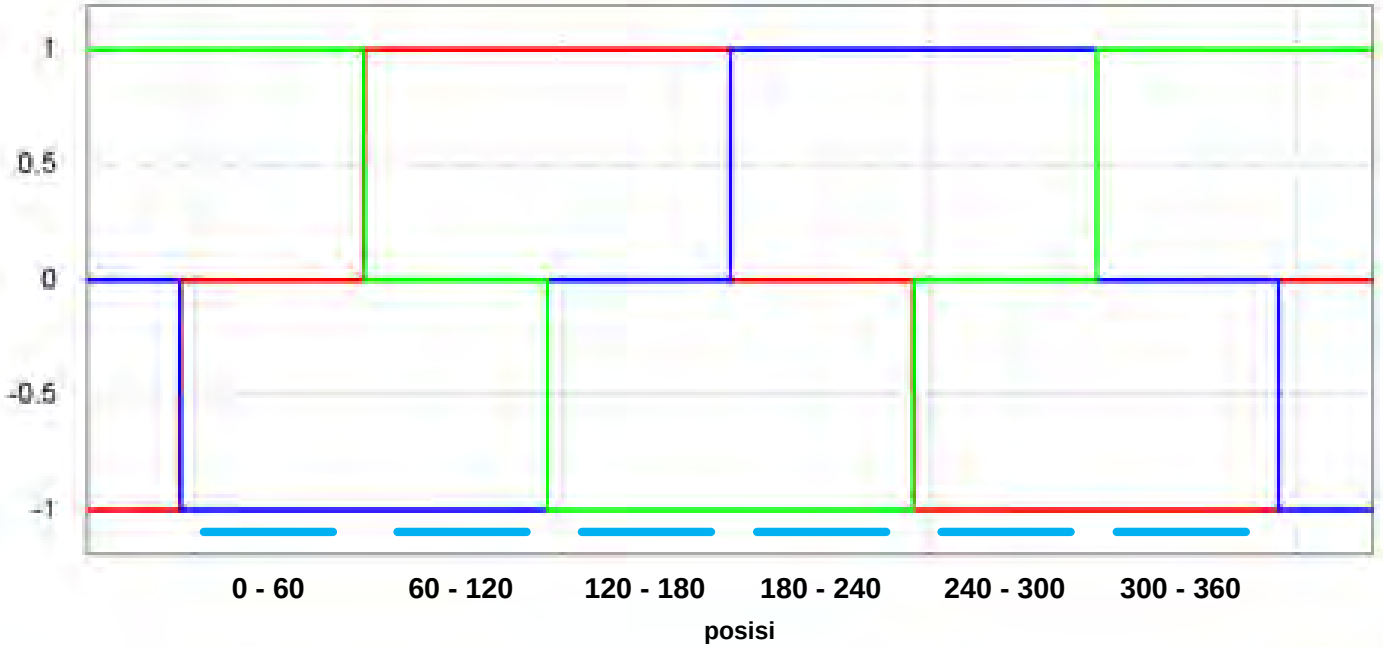
$$C_2 = \frac{P_{rating}}{2\ x\ \ \omega\ x\ \%ripple\ x\ V_{dc\_rating}{}^2}$$

$$C_2 = \frac{874}{2\ x\ \ 314\ x\ 0.03\ x\ 100^2} = \mathbf{4.63\ mF}$$

Desain Sistem Kontrol

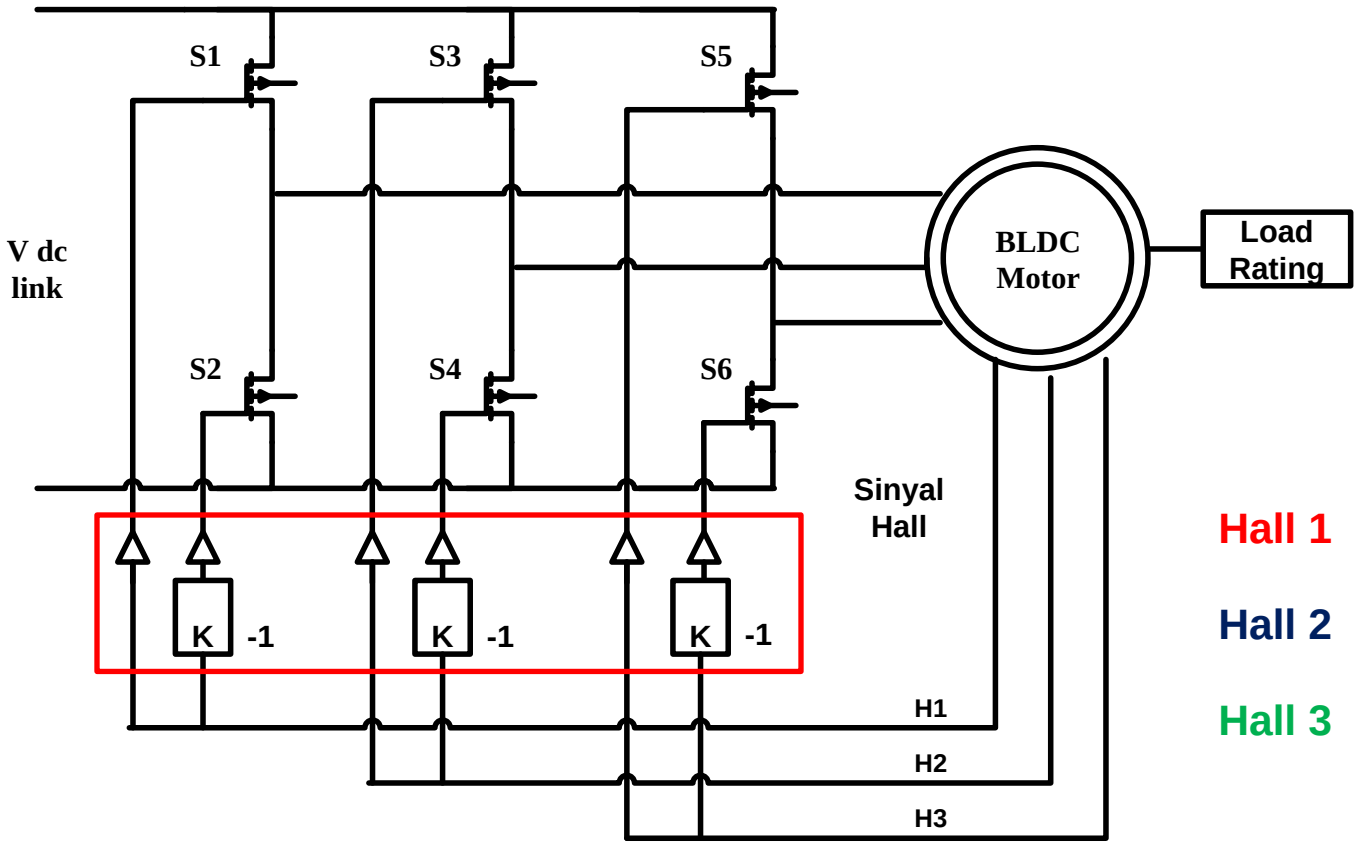
VSI - BLDC





Desain Sistem Kontrol

VSI - BLDC



Hall 1 → S1, S2

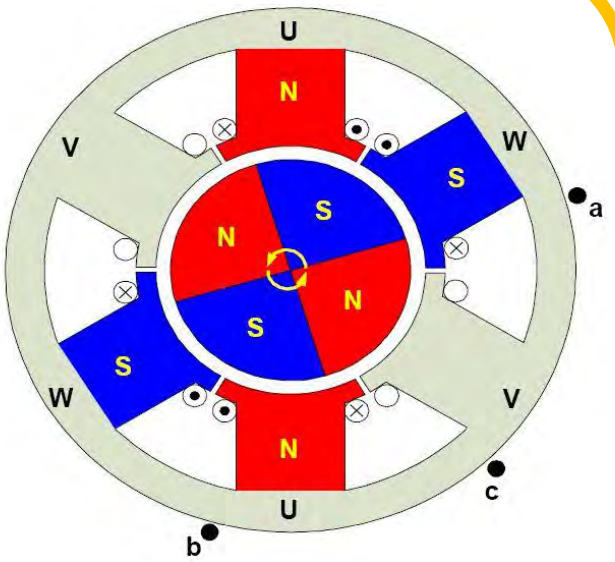
Hall 2 → S3, S4

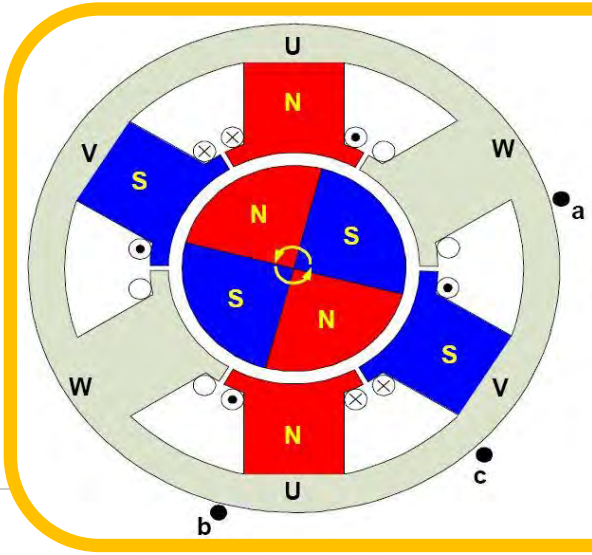
Hall 3 → S5, S6

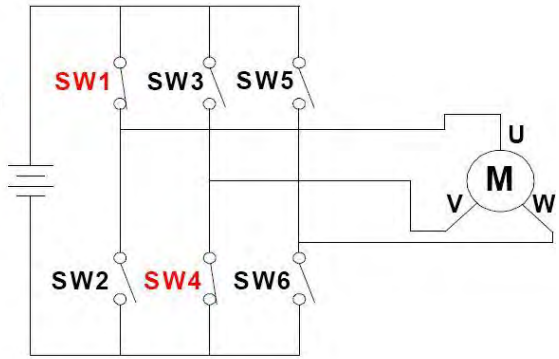
Desain Sistem Kontrol

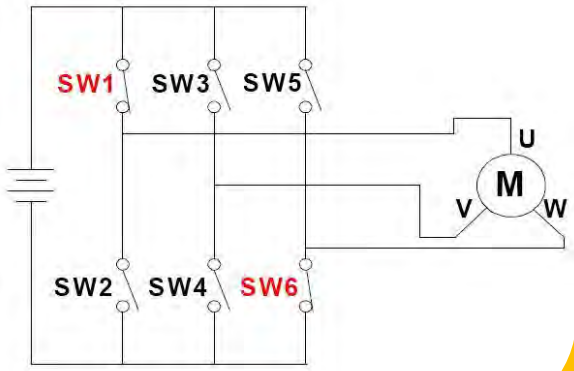
VSI - BLDC

Interval switching	Sensor Hall			Switch ON	
	H1	H2	H3		
0^o-60^o	0	-1	1	S1	S4
60^o-120^o	1	-1	0	S1	S6
120^o-180^o	1	0	-1	S3	S6
180^o-240^o	0	1	-1	S3	S2
240^o- 300^o	-1	1	0	S5	S2
300^o- 360^o	-1	0	1	S5	S4



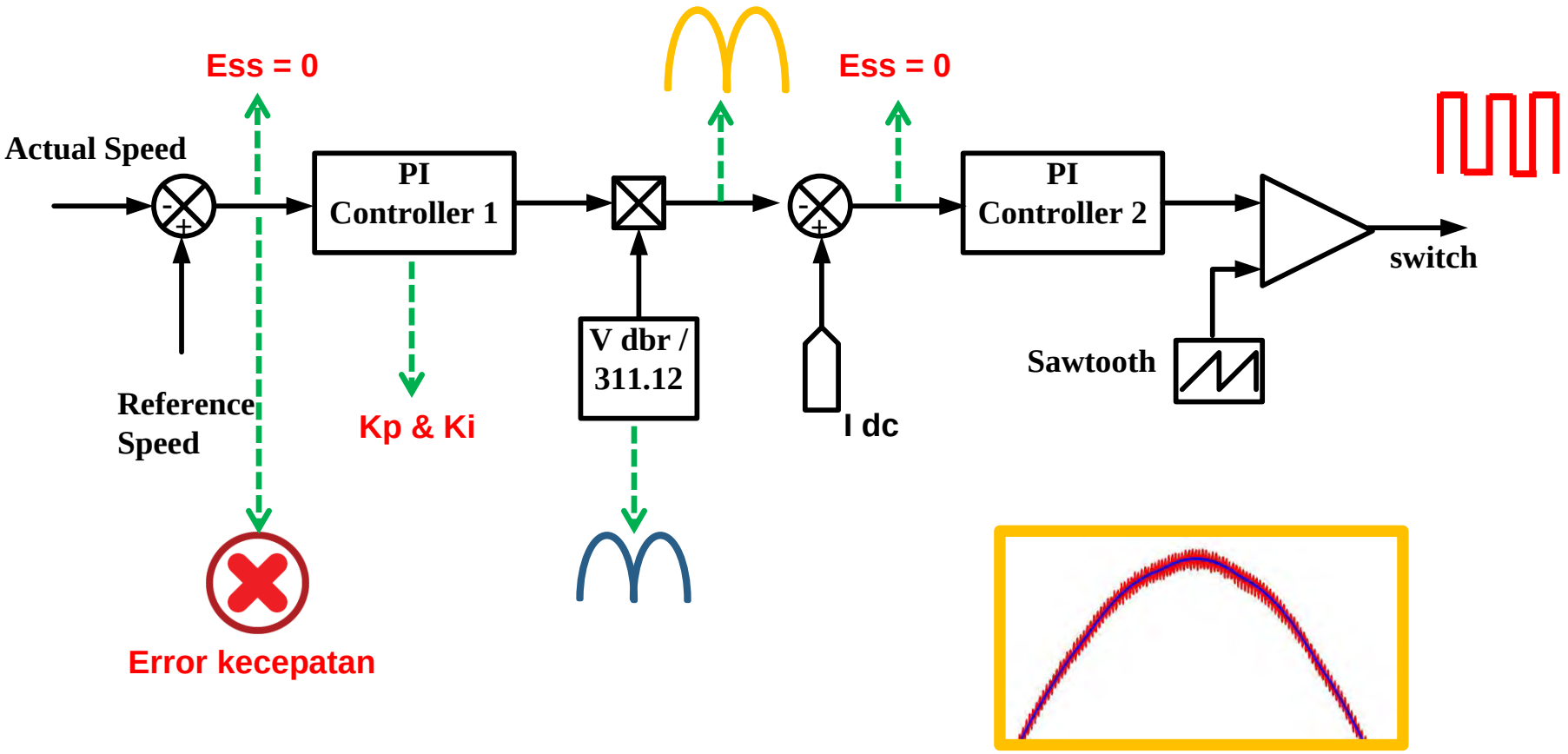






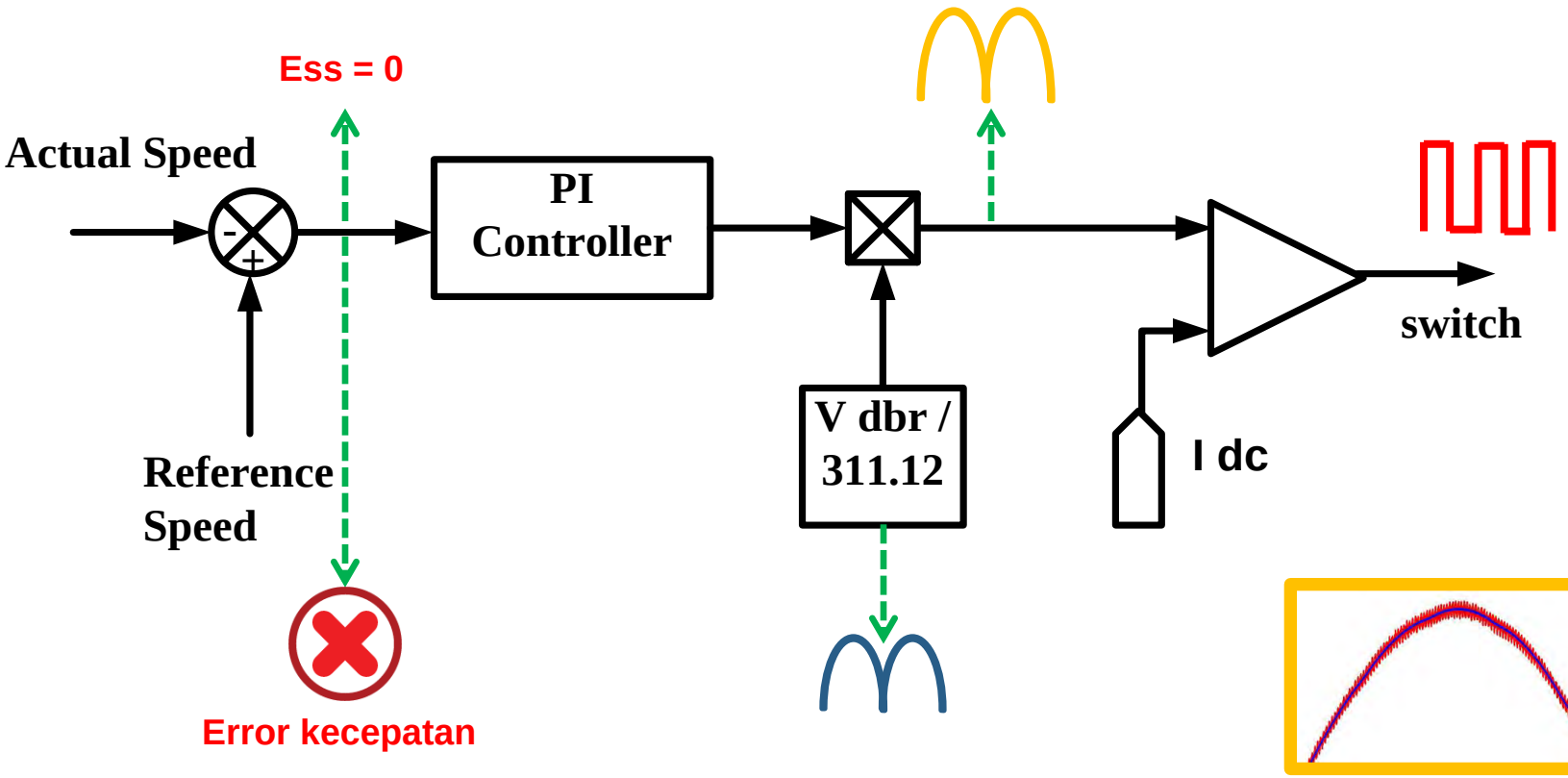
Desain Sistem Kontrol

Average Current Control



Desain Sistem Kontrol

Hysteresis Current Control

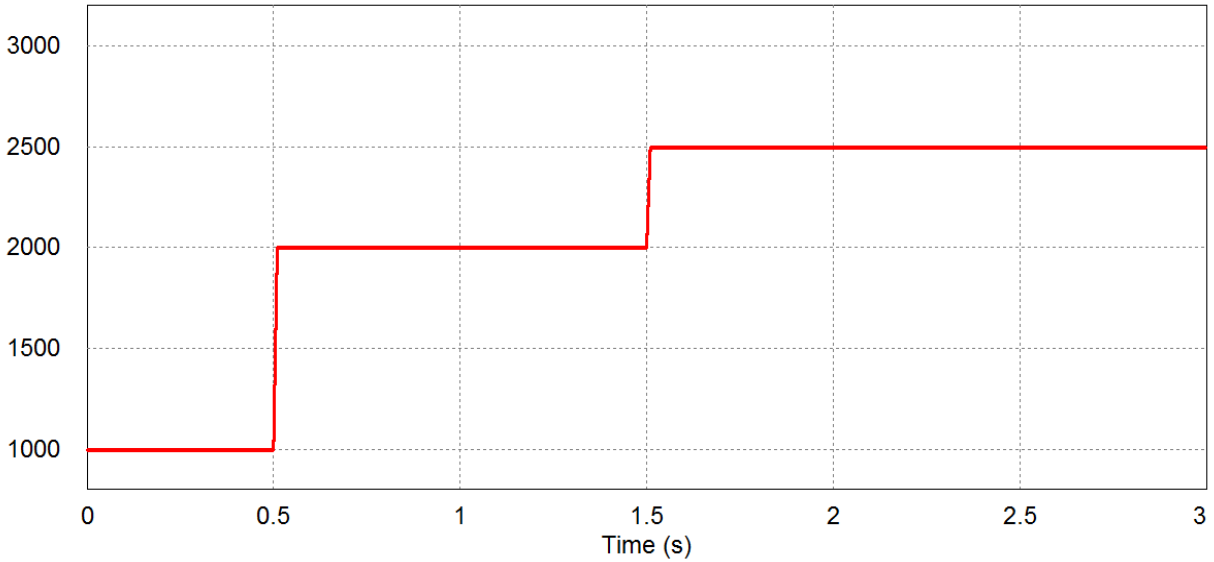


Hasil dan Pembahasan

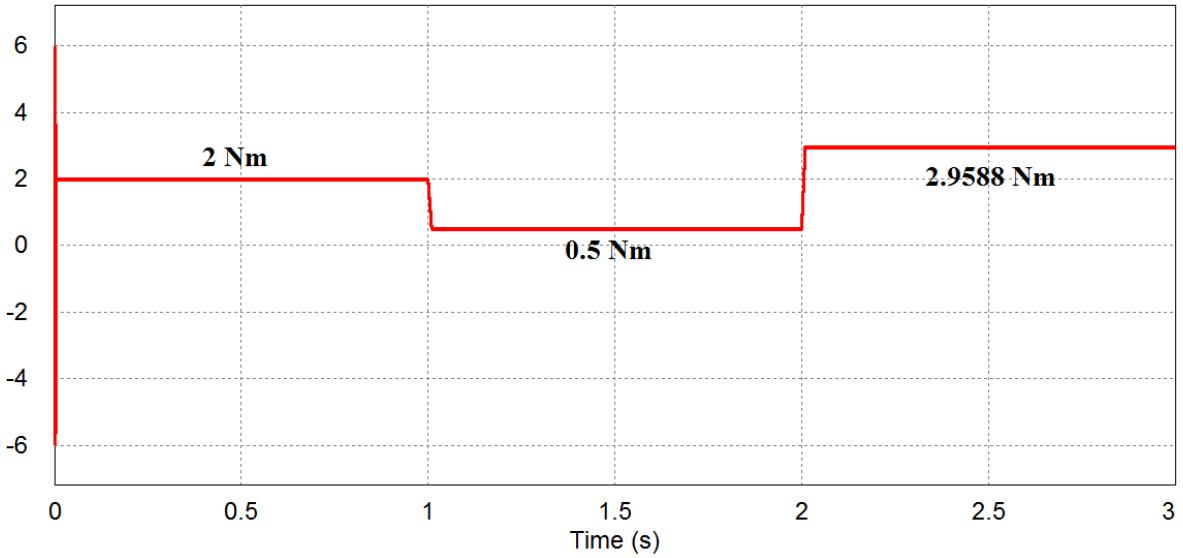
1. CCM Hysteresis
2. CCM Average
3. DCM Hysteresis
4. DCM Average

Hasil dan Pembahasan

Skenario Kecepatan

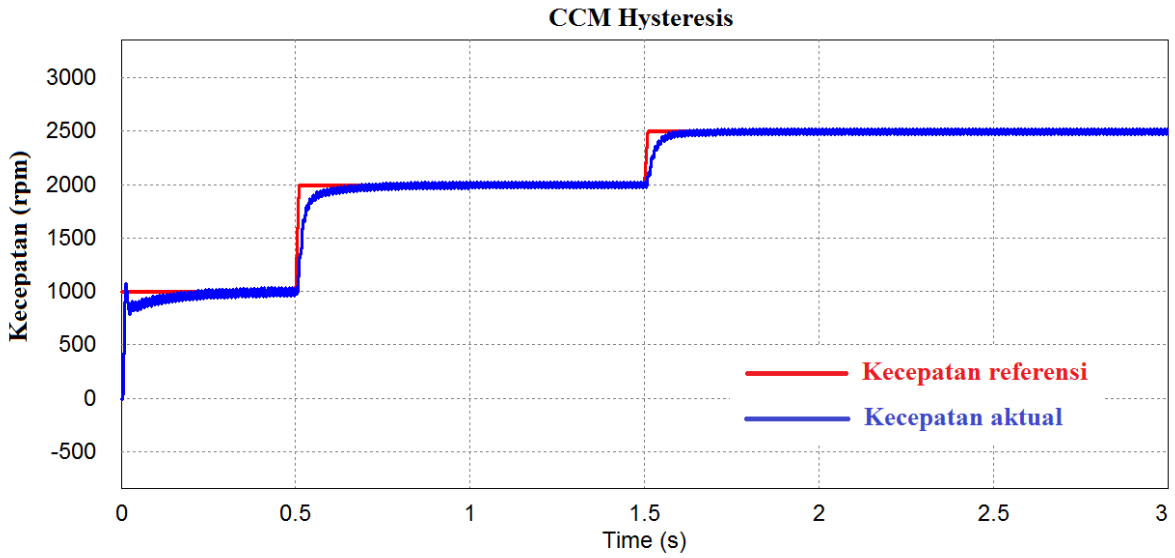


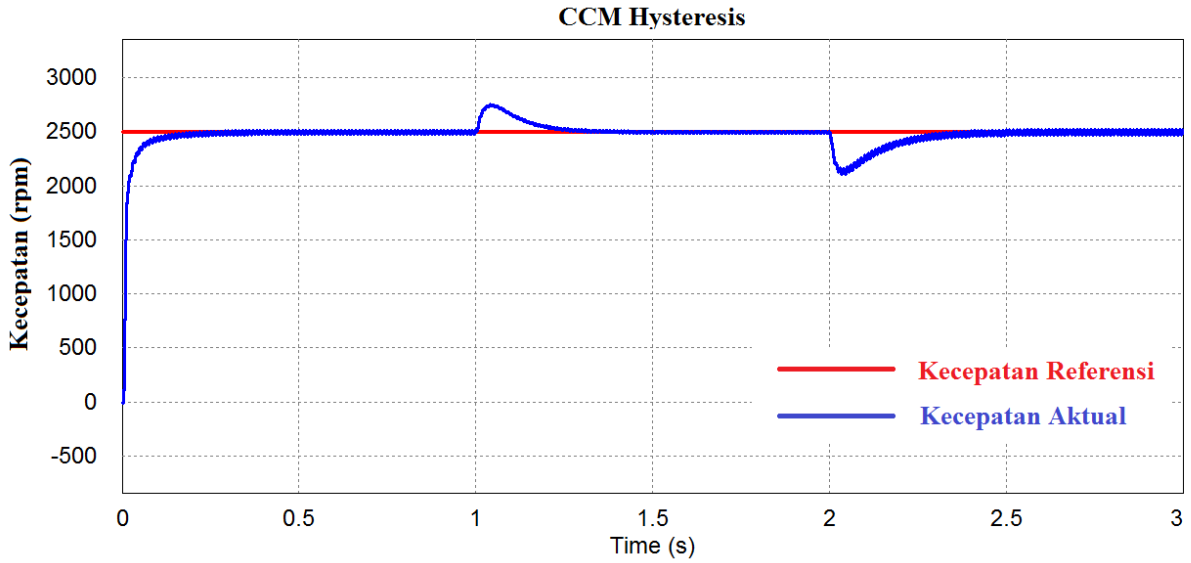
Skenario Pembebanan



Hasil dan Pembahasan

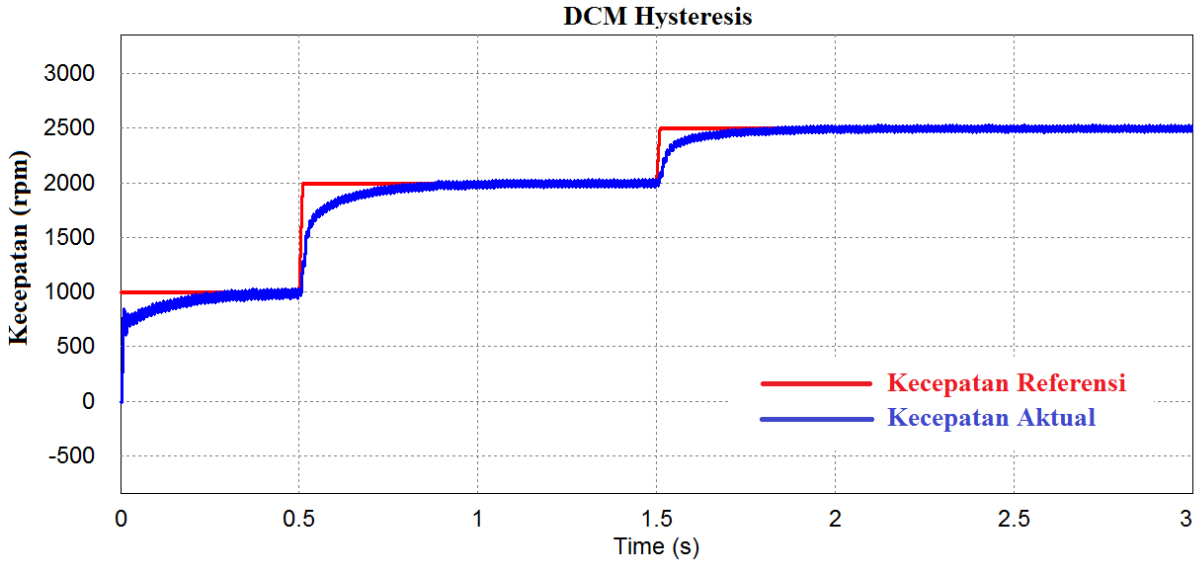
CCM Hysteresis

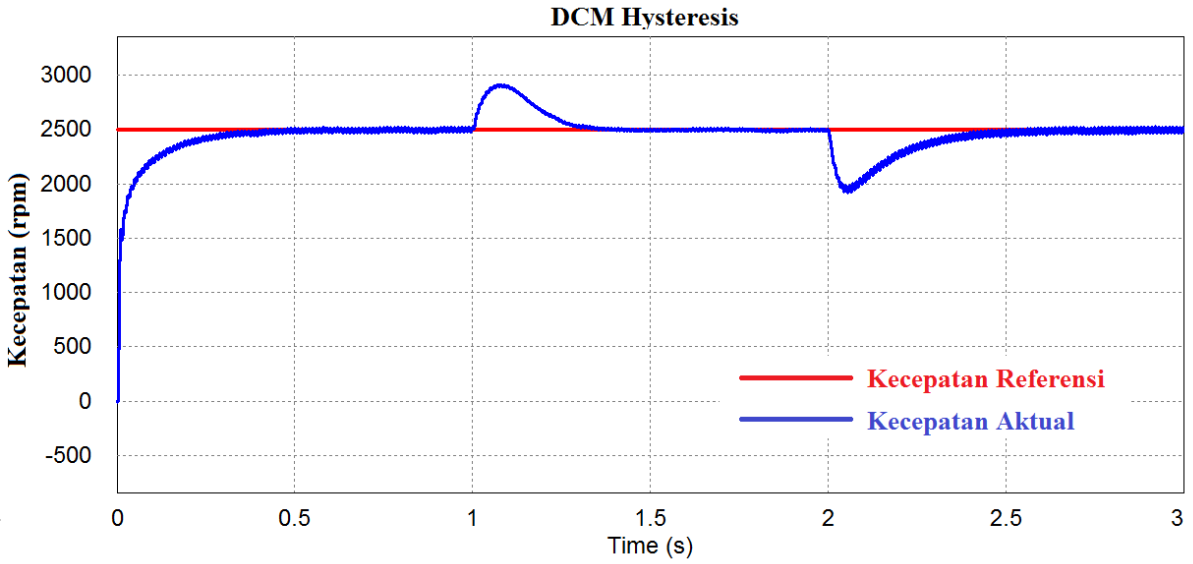




Hasil dan Pembahasan

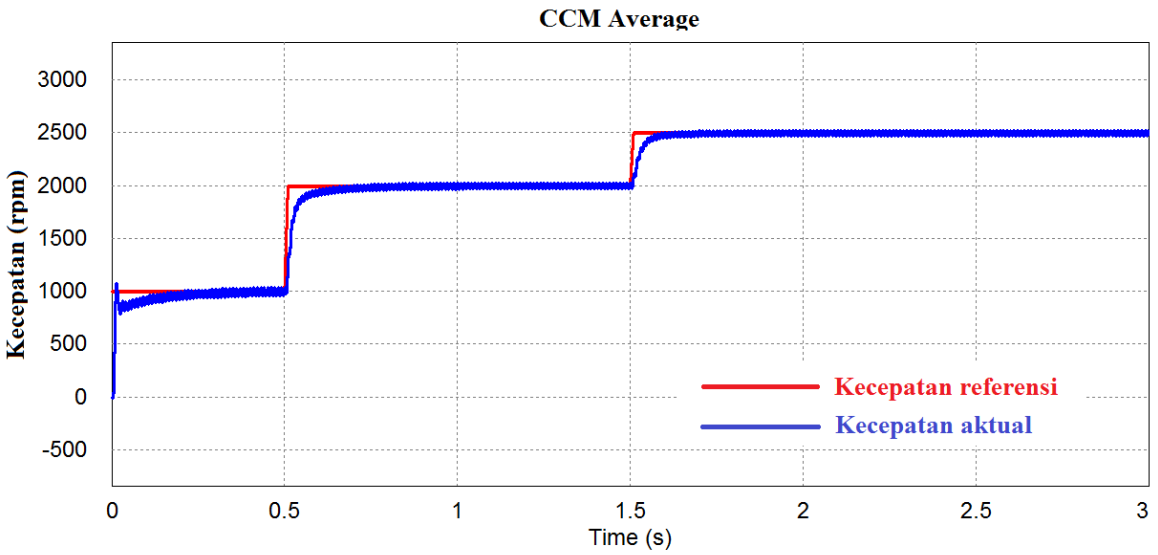
DCM Hysteresis

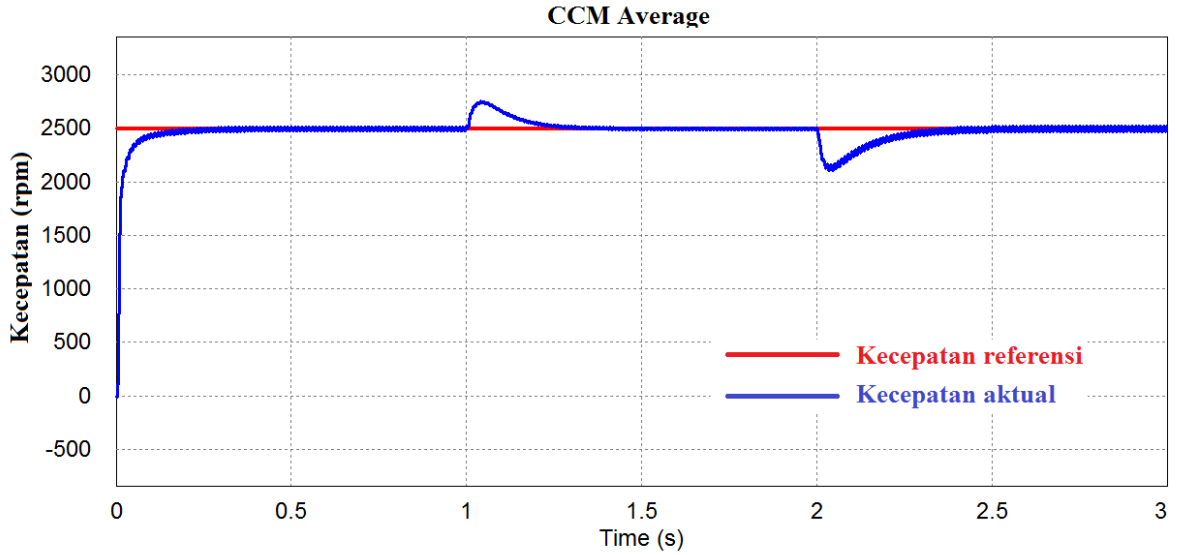




Hasil dan Pembahasan

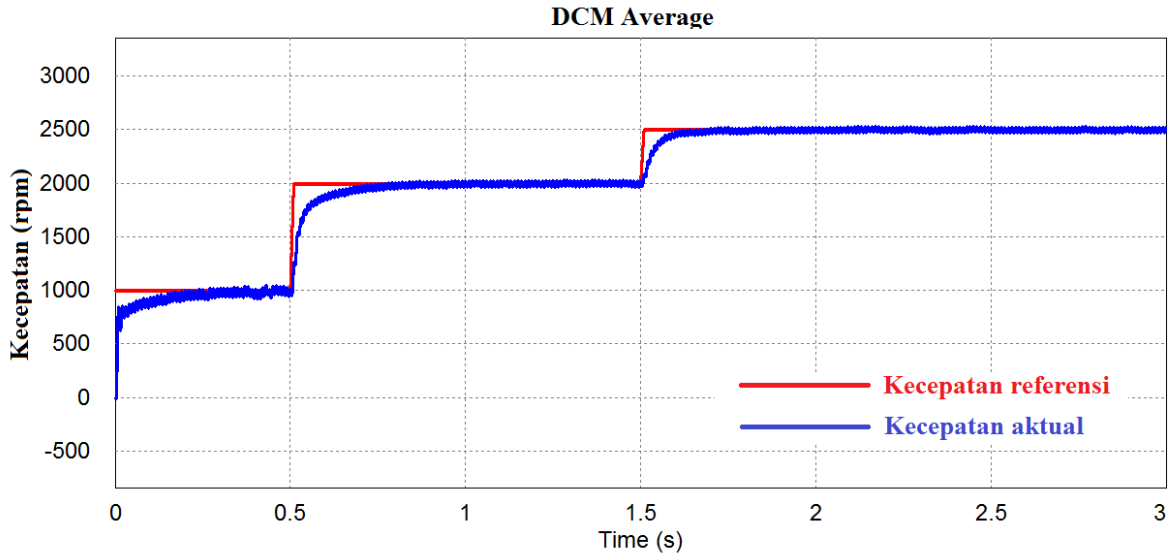
CCM Average

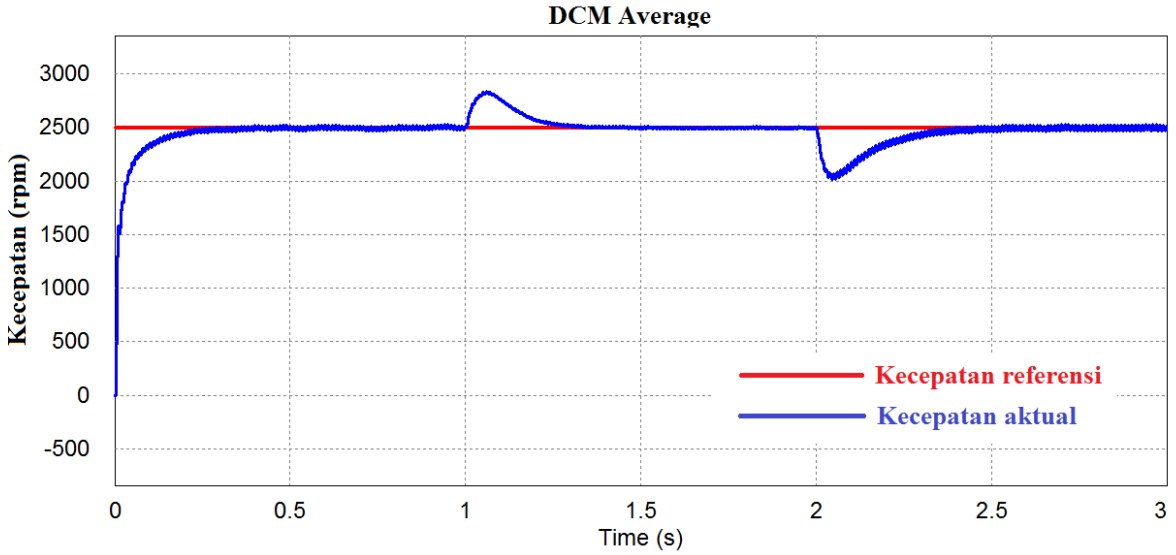




Hasil dan Pembahasan

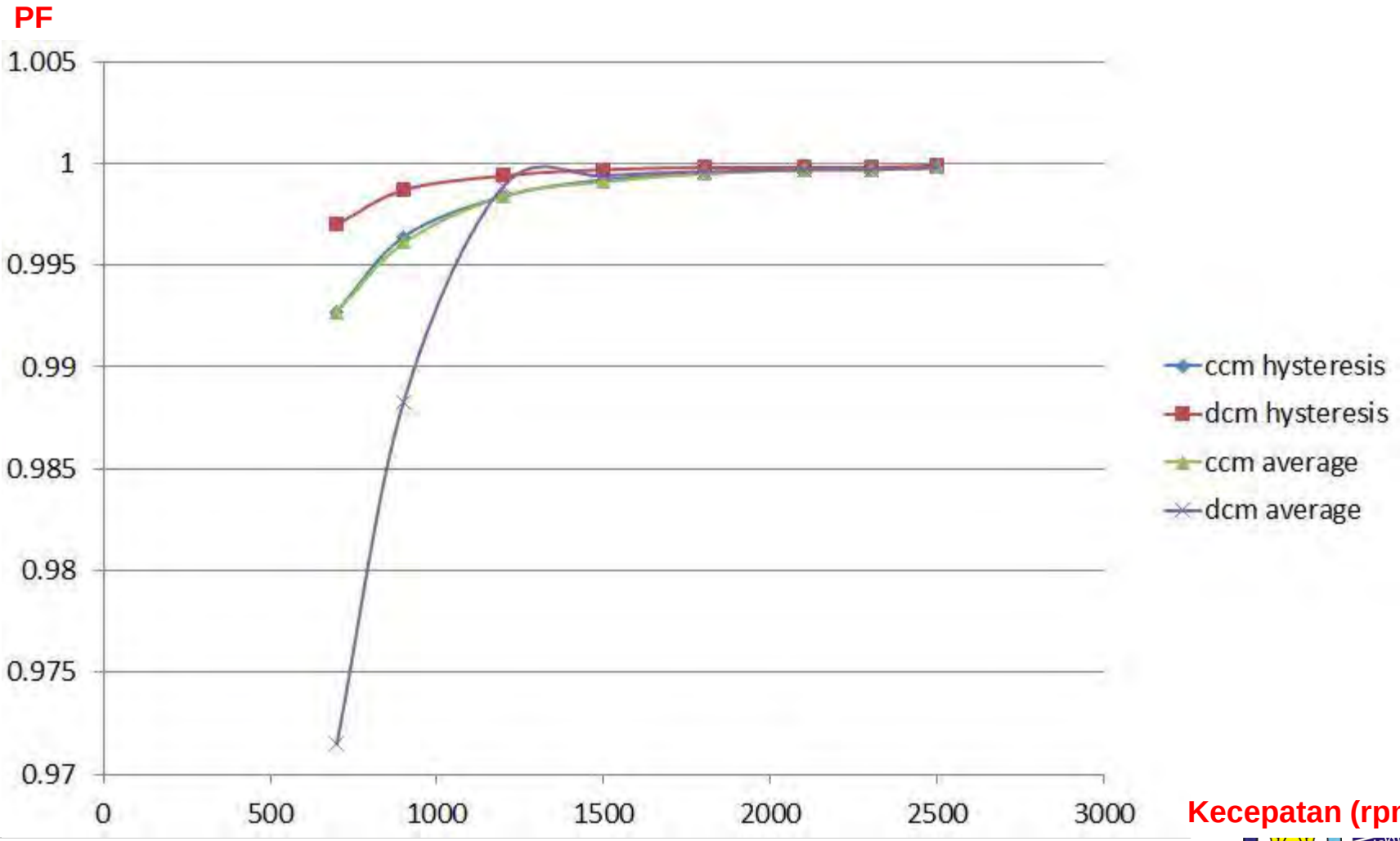
DCM Average





Hasil dan Pembahasan

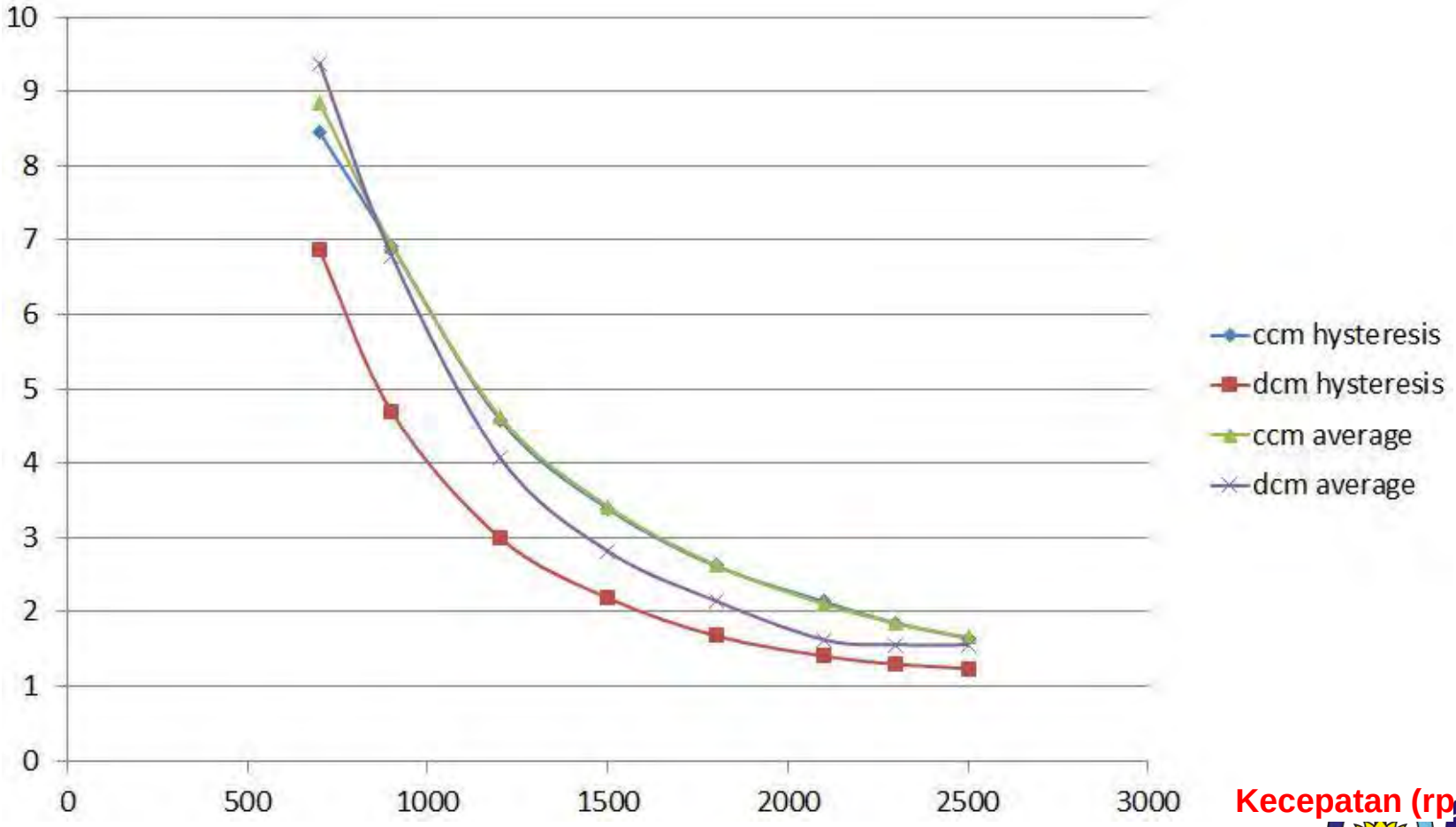
Nilai Faktor Daya



Hasil dan Pembahasan

Nilai THD Arus

THD Arus



Kesimpulan

1. Pada pengujian kecepatan, sistem kontrol yang didesain bisa membuat kecepatan motor brushless DC mengikuti kecepatan referensi yang diberikan
2. Pada pengujian pembebanan yang diberikan, motor brushless DC bisa mempertahankan kecepatannya sekalipun adanya lonjakan kecepatan maupun penurunan kecepatan sesaat
3. Konverter SEPIC berbasis *power factor correction* dapat memperbaiki faktor daya pada sistem dari 0.73 menjadi 0.999 pada kecepatan dan beban rating
4. Konverter SEPIC berbasis *power factor correction* dapat menurunkan nilai THD arus dari 74.39% menjadi 1.24%

Daftar Pustaka

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Terimakasih