DESAIN DAN IMPLEMENTASI INTERLEAVED BOOST CONVERTER UNTUK APLIKASI PHOTOVOLTAIC

AUFAR GUSVIANDI PRATAMA

NRP 2210100081

Dosen Pembimbing:

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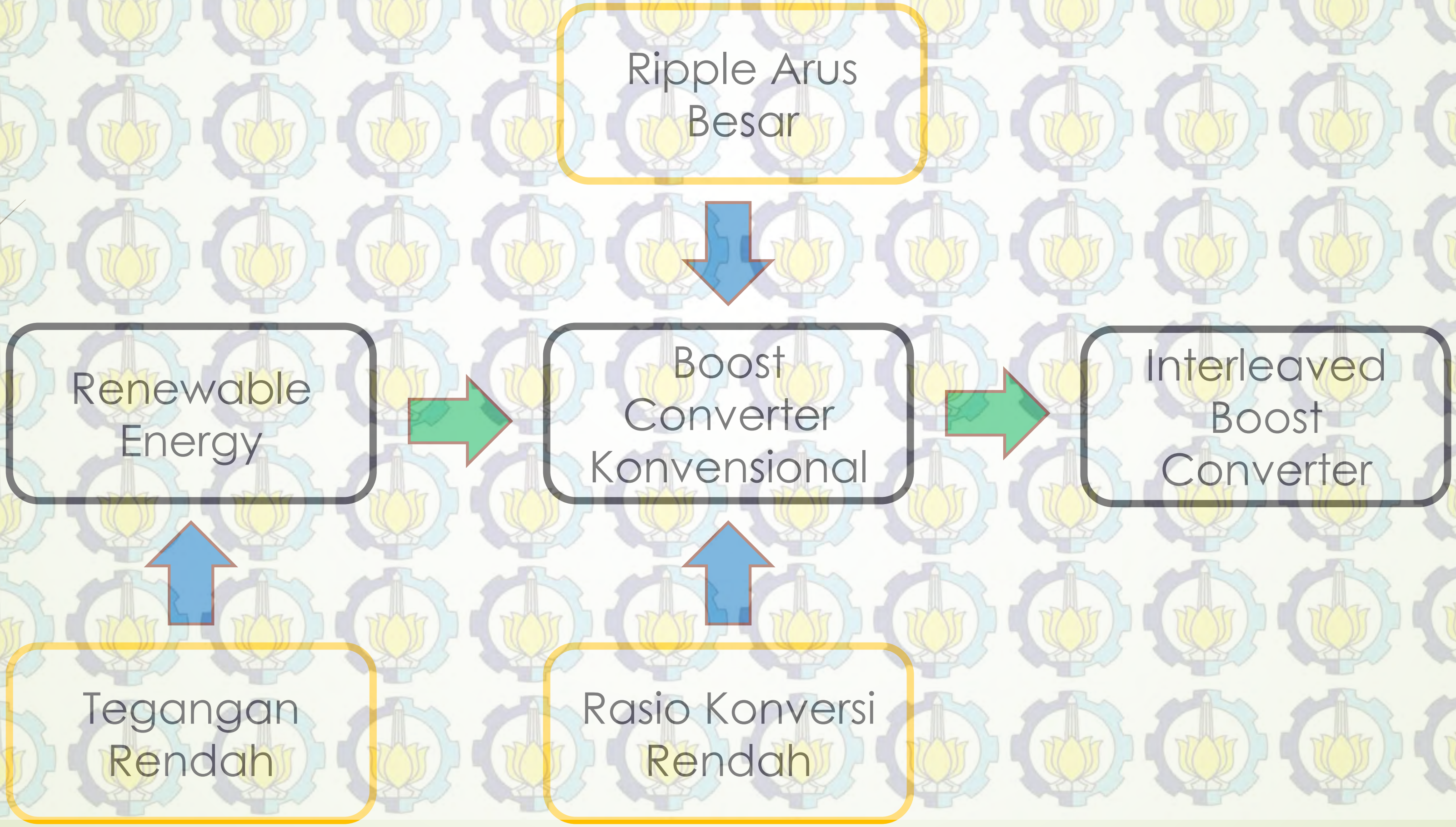
Latar Belakang

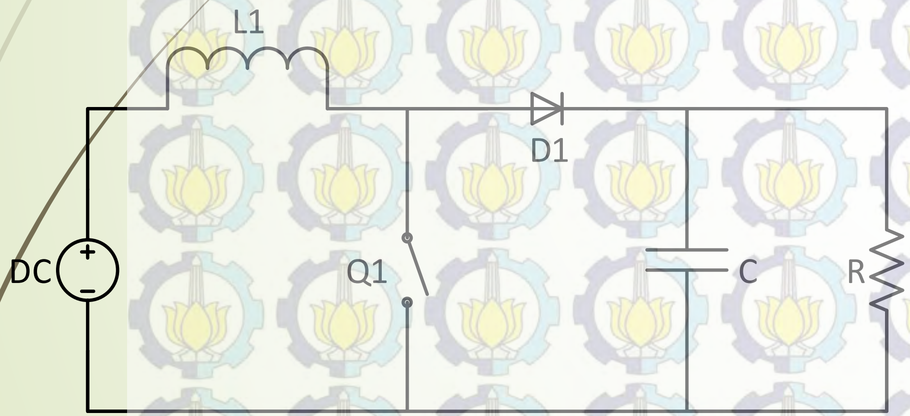


Tujuan

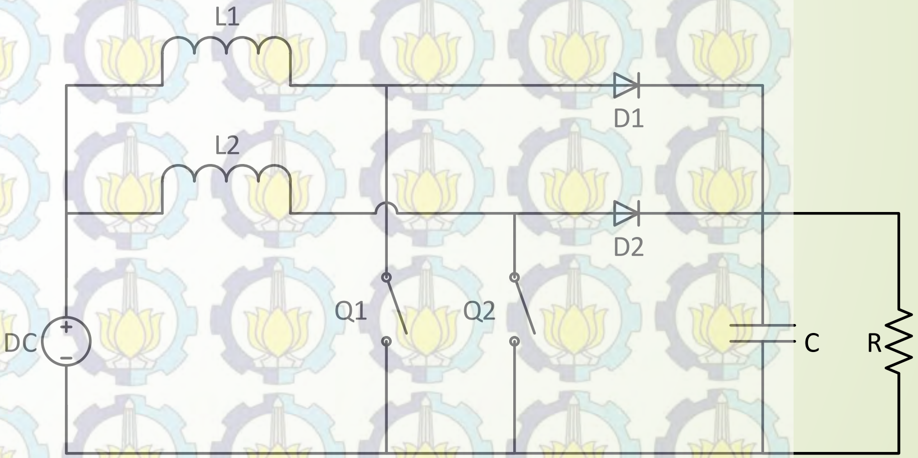
- Mengetahui hal-hal yang berkaitan dengan Interleaved Boost Converter
- Mendesain dan mengimplementasikan Interleaved Boost Converter
- Menganalisa hasil implementasi Interleaved Boost Converter dan membandingkannya dengan Boost Converter konvensional

Rangkaian Utama

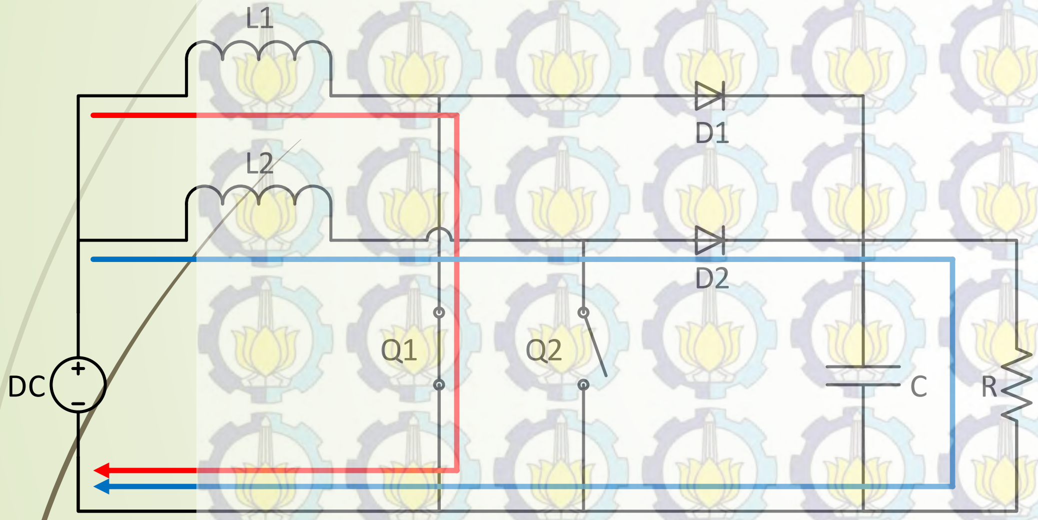
Boost Converter Konvensional



Interleaved Boost Converter



Analisis Steady State



- Mode Operasi 1:

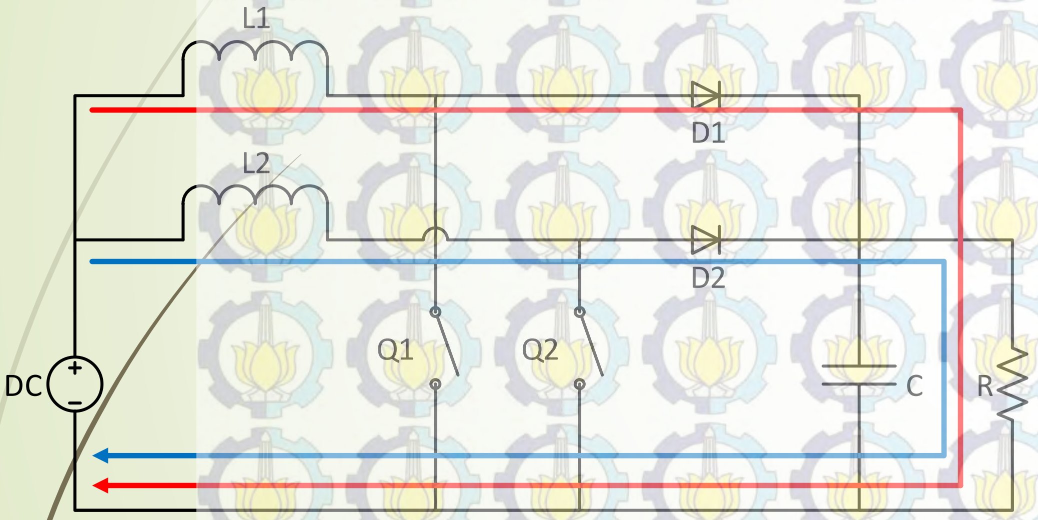
  Q1 : Closed

  Q2 : Open

- $\Delta i_{L1}\left(t_{charge}\right) = \frac{(V_i)}{L_1}(DT)$

- $\Delta i_{L_2}\left(t_{discharge}\right) = \frac{(V_i - V_o)}{L_2}(1-D)T$

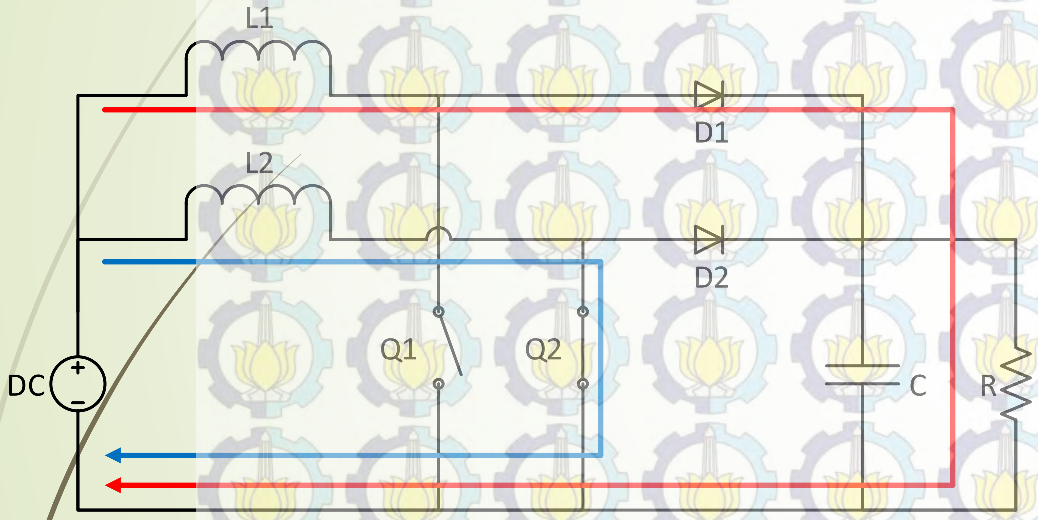
Analisis Steady State



- Mode Operasi 2:
  Q1 : open
  Q2 : open

- $$\frac{\Delta i_{L_{1,2}}(t_{discharge})}{\Delta t_{off}} = \frac{V_i - V_o}{L_{1,2}}$$

Analisis Steady State



- Mode Operasi 3:

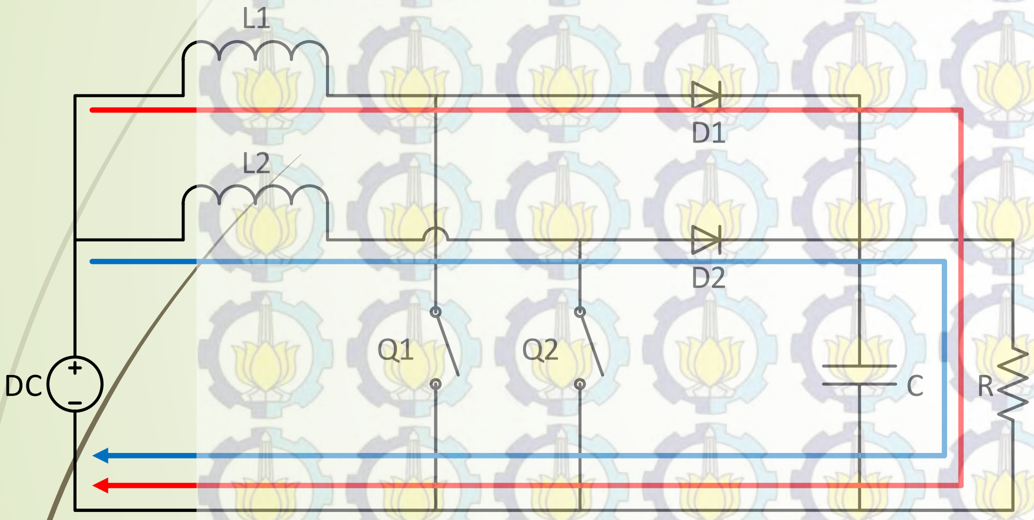
  Q1 : open

  Q2 : Closed

- $\Delta i_{L_1}(t_{discharge}) = \frac{(V_i - V_o)}{L_1}(1-D)T$

- $\Delta i_{L2}(t_{charge}) = \frac{(V_i)}{L_2}(DT)$

Analisis Steady State



- Mode Operasi 4:
  Q1 : open
  Q2 : open
- $$\frac{\Delta i_{L_{1,2}}(t_{discharge})}{\Delta t_{off}} = \frac{V_i - V_o}{L_{1,2}}$$

Hasil Penentuan Persamaan

- $D = 1 - \frac{V_i}{V_o}$
- $L_1 = L_2 = \frac{V_i \times D}{\Delta i_L \times f}$
- $C = \frac{i_o \times D}{\Delta V_o \times f}$

Bentuk Gelombang Operasi

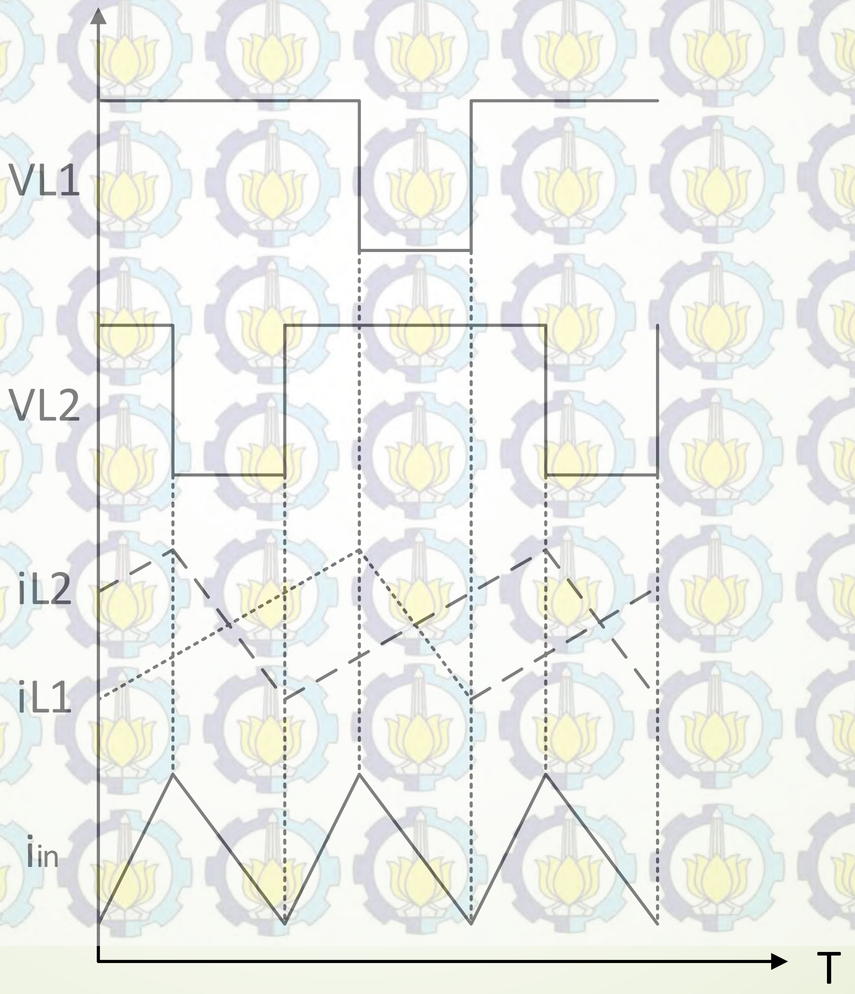
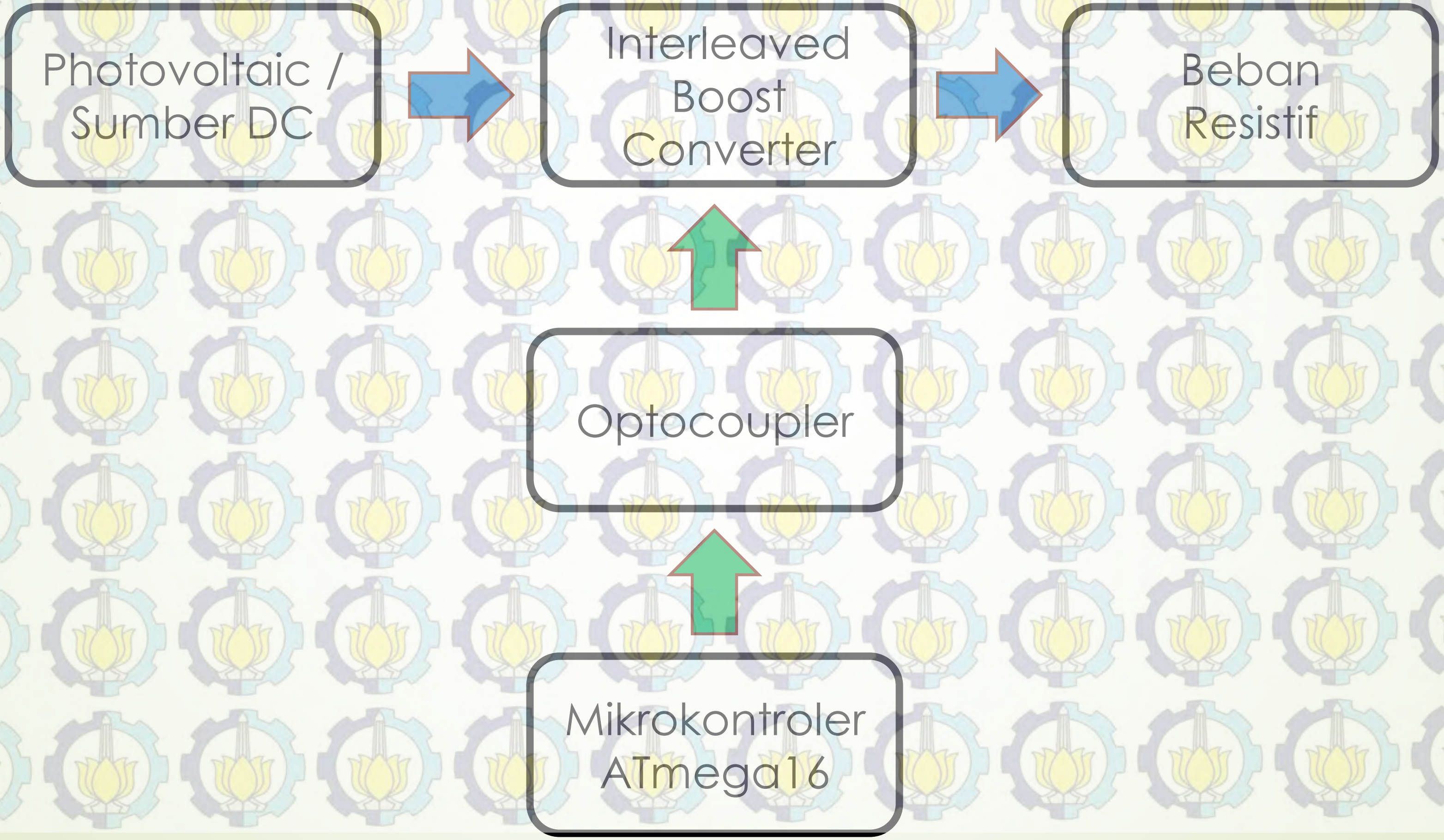


Diagram Blok Sistem



Penentuan Parameter Rangkaian

Parameter	Nilai
Tegangan input	18 V
Tegangan output	60 V
Daya output	50 W / 36 W
Beban resistansi	72 Ω / 100 Ω
Frekuensi switching	20 kHz
Ripple arus induktor	25 %
Ripple tegangan kapasitor	1 %

Rating Photovoltaic pada Simulasi

Spesifikasi	Nilai
Model	eS50236-PCM
Maximum power	50 Wp
Short circuit current	3.25 A
Maximum Power Current	2.91 A
Open Circuit Voltage	21.75 V
Nominal Voltage	17.24 V
FF	0.710

Perhitungan Parameter

Duty Cycle (D)

- $D = 1 - \frac{V_i}{V_o}$

$$D = 1 - \frac{18}{60}$$

$$D = 0.7$$

Kapasitor (C)

- $C = \frac{i_o \times D}{\Delta V_o \times f}$
- $\Delta V_o = ripple\ V_o \times V_o$

$$\Delta V_o = 0.01 \times 60$$

$$\Delta V_o = 0.6$$

- $C = \frac{0.6 \times 0.7}{0.6 \times 20000}$

$$C = 35\ \mu F$$

Perhitungan Parameter

Induktor (L)

- $L_1 = L_2 = \frac{V_i \times D}{\Delta i_L \times f}$

- $I_L = \frac{V_o}{V_i} \times \frac{I_o}{2}$

$I_L = \frac{60}{18} \times \frac{0.6}{2}$

$I_L = 1\ A$

- $\Delta i_L = ripple\ I_L \times I_L$

$\Delta i_L = 0.25 \times 1$

$\Delta i_L = 0.25$

- $L_1 = L_2 = \frac{18 \times 0.7}{0.25 \times 20000}$

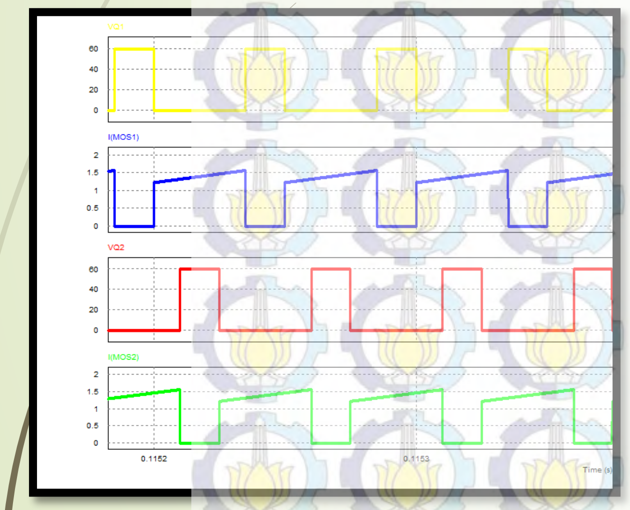
$L_1 = L_2 = 2.52\ mH$

Komponen yang Digunakan Pada Prototype

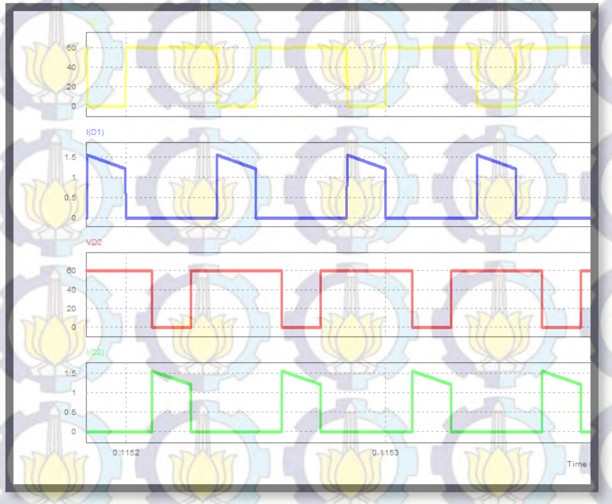
Parameter	Type	Nilai	Jumlah
Induktor (L_1 & L_2)	CS572060	2.52 *mH*	2
Kapasitor (C_O)	elco	47 *μF*	1
MOSFET	IRFP460	20 A / 500 V	2
Optocoupler	TLP250	1 MHz (max) / 35 V	2
Mikrokontroler	ATmega16	20 kHz	1
Dioda	BYC10-600	10 A / 600 V / 19 ns	2

Analisa arus dan tegangan simulasi

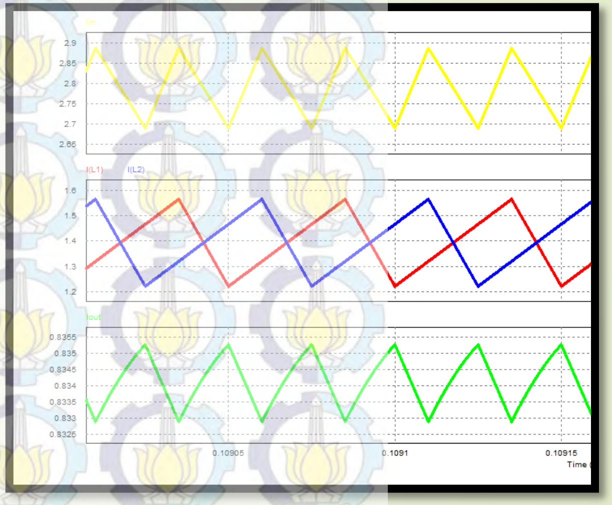
$V_Q 1, 2$ & $I_{DS} 1, 2$



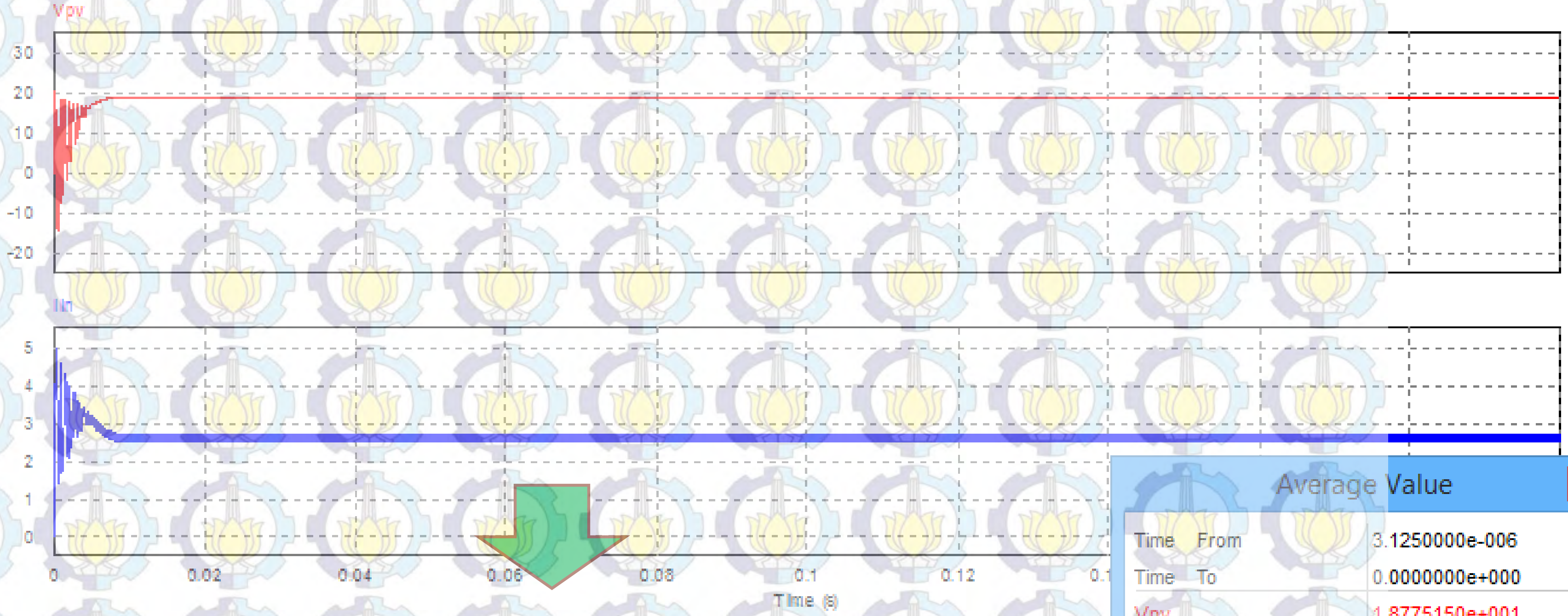
$V_D 1, 2$ & $I_D 1, 2$

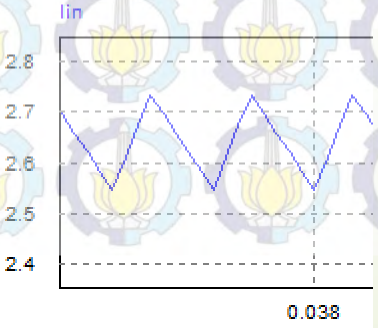


I_{in}, I_L 1, 2 & I_{out}

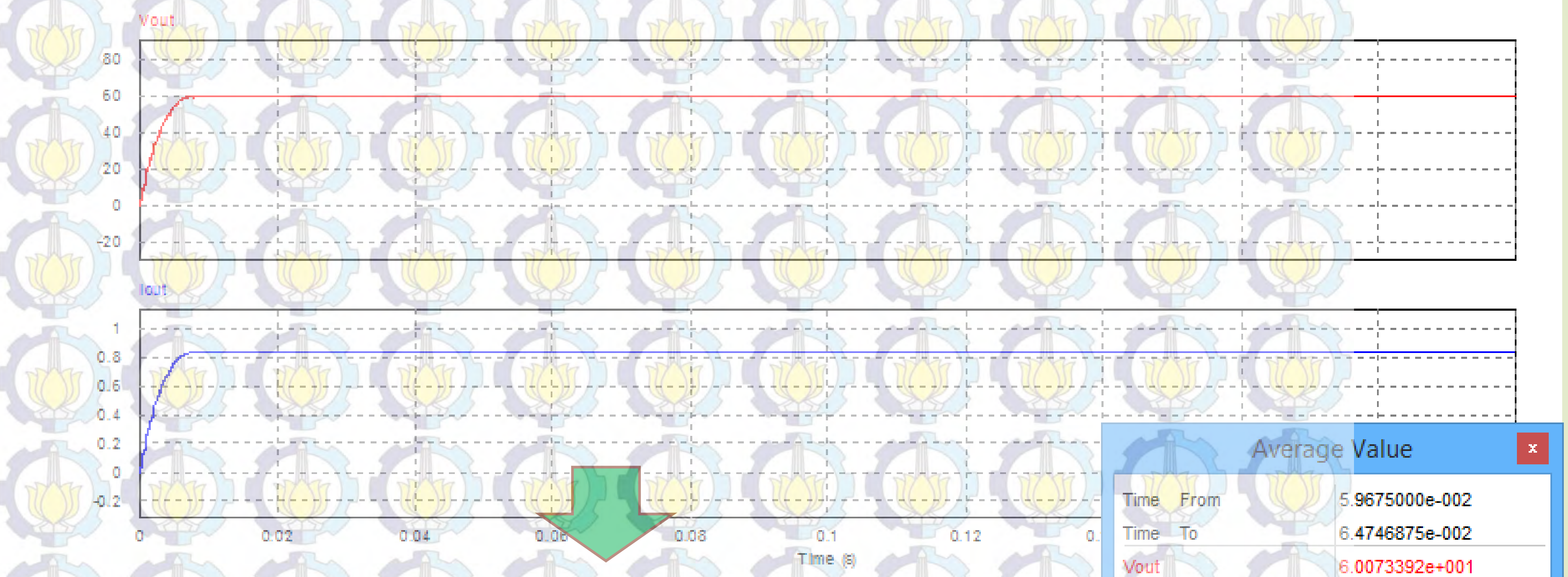


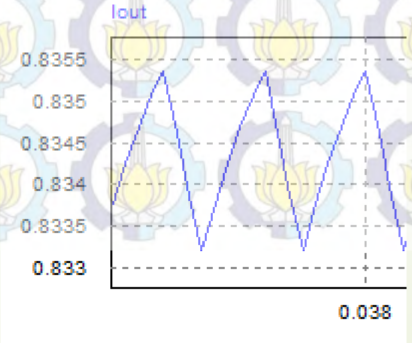
Tegangan dan Arus Input





Tegangan dan Arus Output





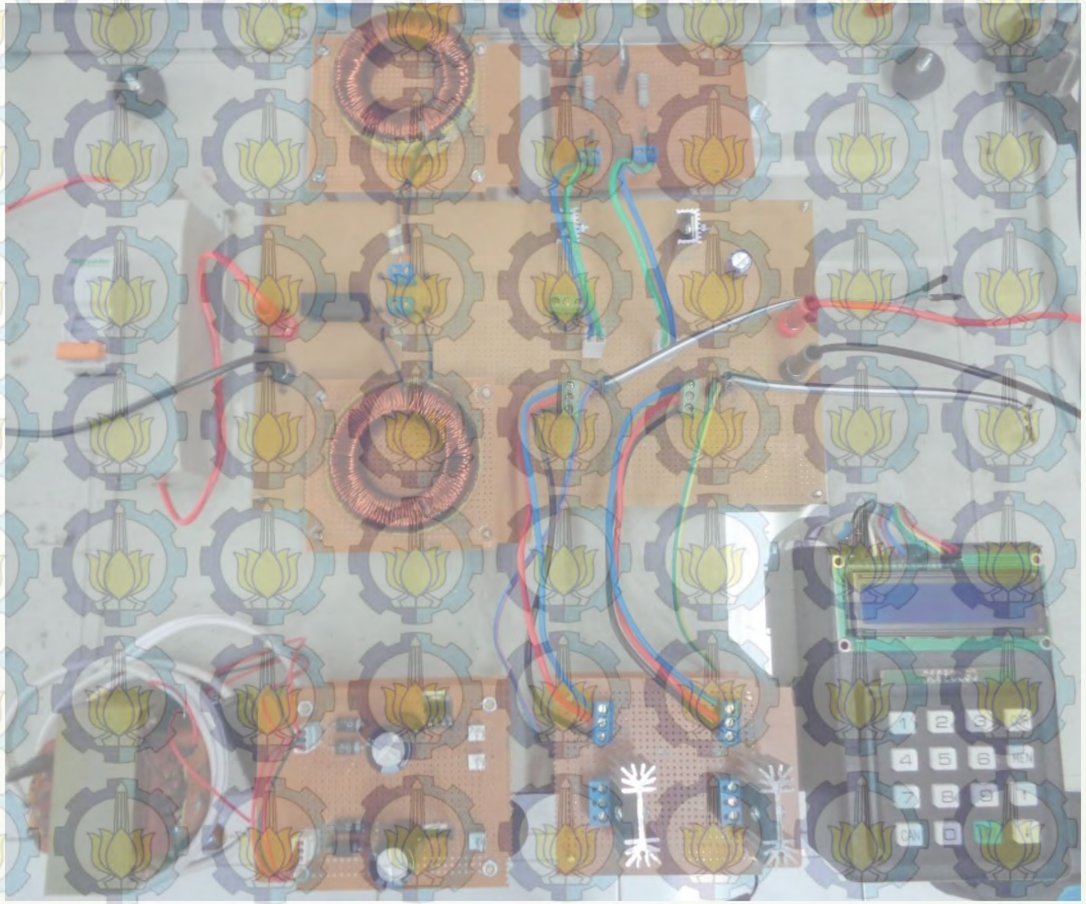
Simulasi Pengujian Perubahan Beban IBC

Vin (V)	Iin (A)	Vout (V)	Iout (A)	Pin (W)	Pout (W)	Beban (Ω)	Pout (%)
17.89	2.810	60.03	0.834	50.271	50.065	72	100
18.73	2.410	60.03	0.750	45.139	45.023	80	90
19.21	2.086	60.04	0.667	40.072	40.047	90	80
19.56	1.793	60.00	0.583	35.071	34.980	102.86	70
19.84	1.517	60.00	0.500	30.097	30.000	120	60
20.09	1.251	60.02	0.417	25.133	25.028	144	50
20.31	0.991	60.00	0.333	20.127	19.980	180	40
20.51	0.739	60.02	0.250	15.157	15.005	240	30

Simulasi Pengujian Perubahan Duty Cycle IBC

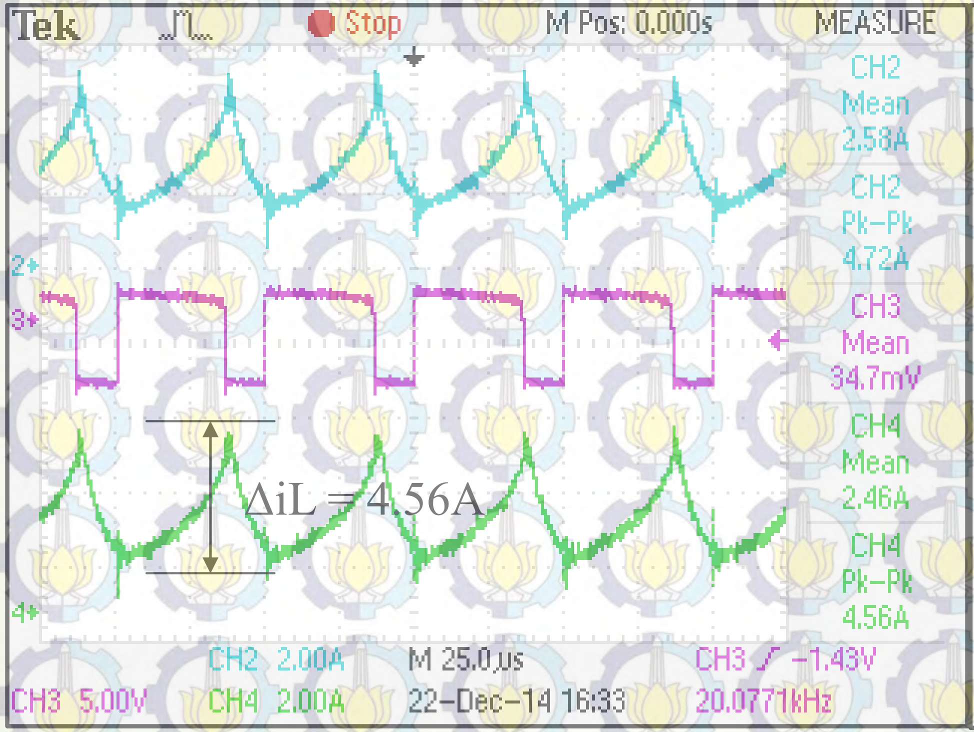
D (%)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Vout Teori	Error (%)
50	20.20	1.126	40.40	0.561	40.40	0
55	19.91	1.451	44.24	0.632	44.24	0
60	19.65	1.709	49.12	0.682	49.12	0
65	19.10	2.172	54.56	0.757	54.57	0
70	17.96	2.784	59.87	0.831	59.87	0

Prototype Interleaved Boost Converter

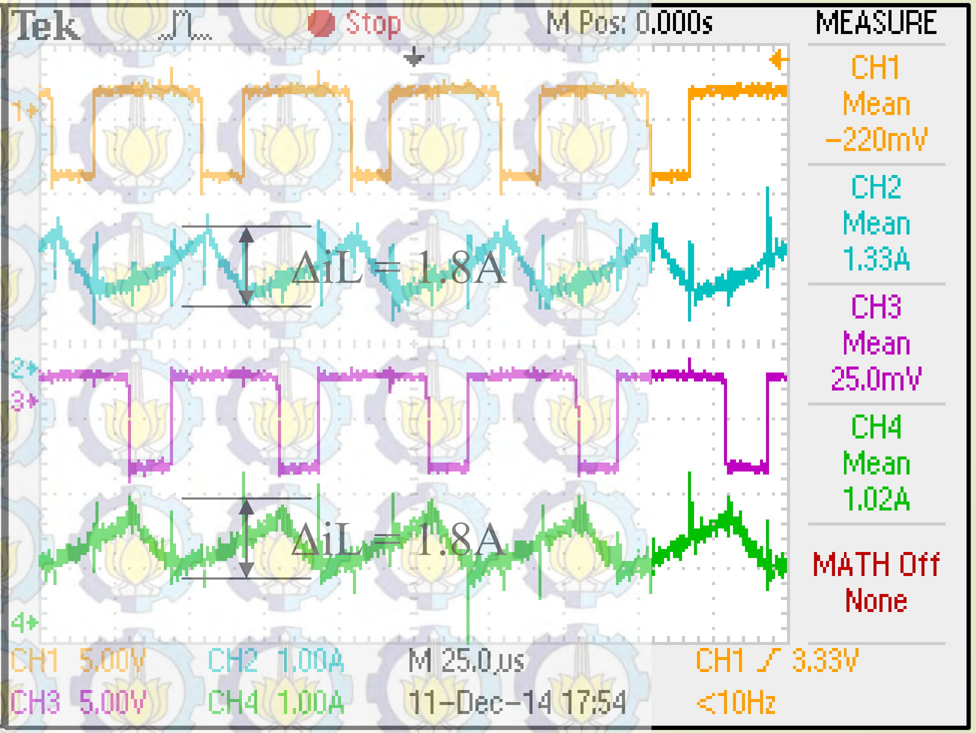


Analisa Arus Induktor

Boost Converter Konvensional



Interleaved Boost Converter



Pengujian Perubahan Beban

Tujuan:

- Mengetahui efisiensi dari masing-masing konverter (Interleaved Boost Converter dan Boost Converter konvensional)

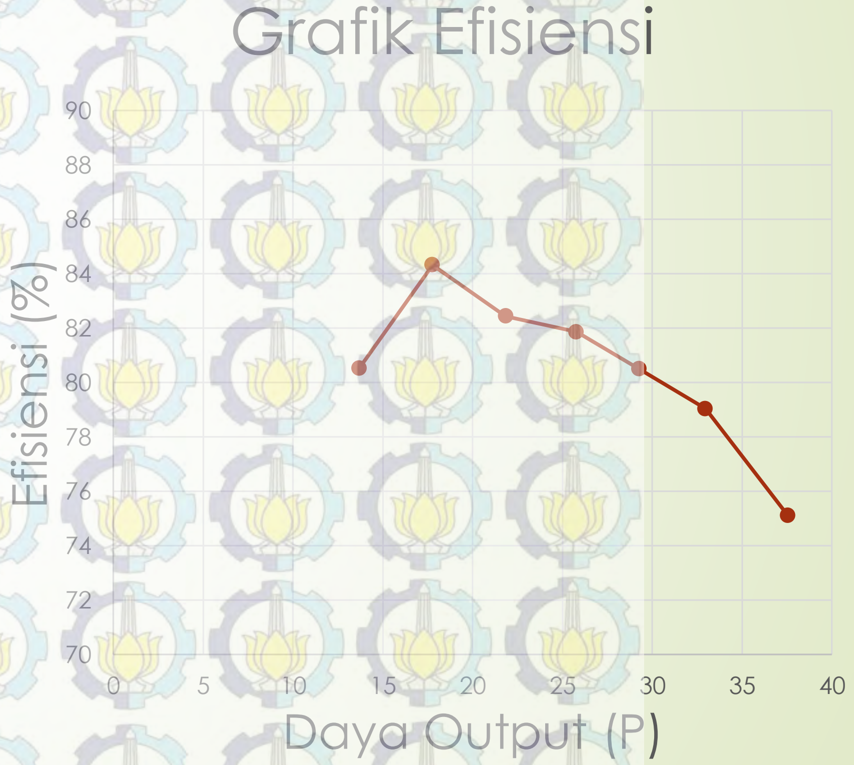
Parameter:

- Vin = 18V
- Vout = 60V

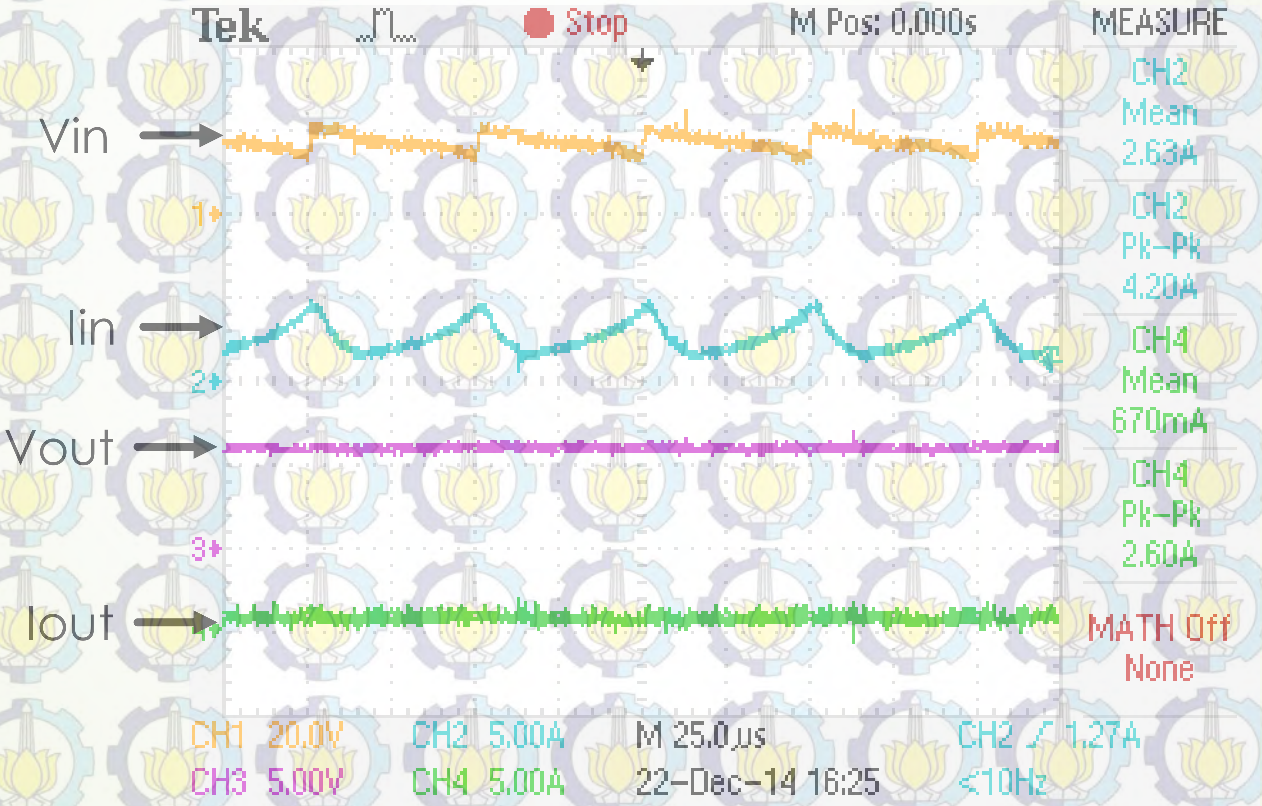
Pengujian Perubahan Beban

Boost Converter Konvensional

Vin (V)	Iin (A)	Vout (V)	Iout (mA)	Pin (W)	Pout (W)	Pout (%)	Efisiensi (%)
17.8	2.81	60.1	625	50.02	37.56	100	75.10
17.9	2.33	59.5	554	41.70	32.96	90	79.03
18.1	2.01	59.4	493	36.38	29.28	80	80.49
18.1	1.74	60.1	429	31.49	25.78	70	81.87
17.9	1.48	60.0	364	26.49	21.84	60	82.44
18.0	1.17	59.0	301	21.06	17.74	50	84.33
18.1	0.94	59.5	230	16.99	13.69	40	80.52



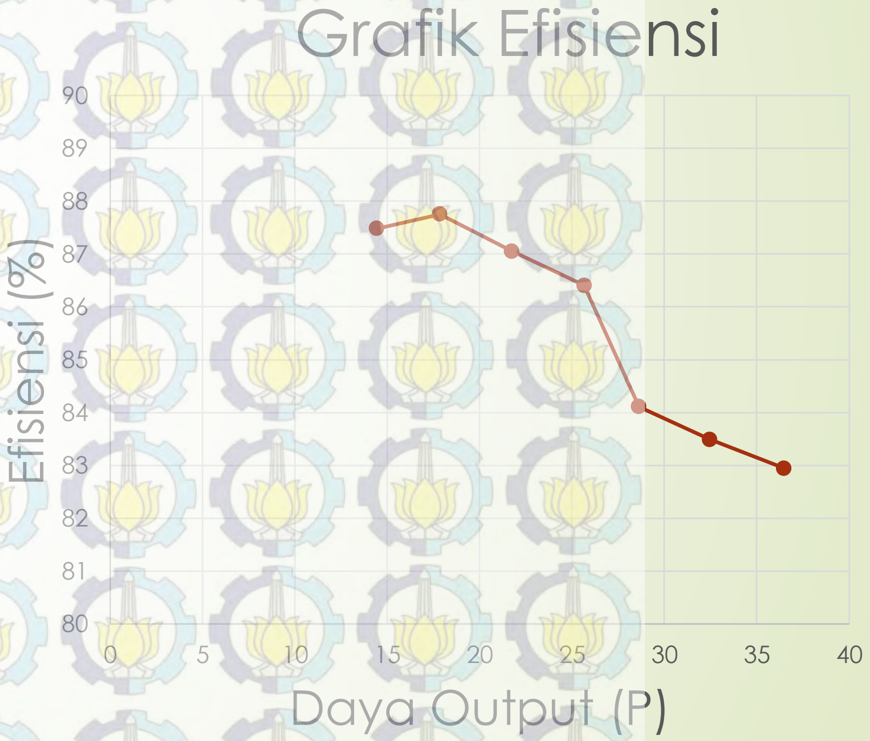
Gelombang Arus dan Tegangan Boost Converter Konvensional (P=100%)



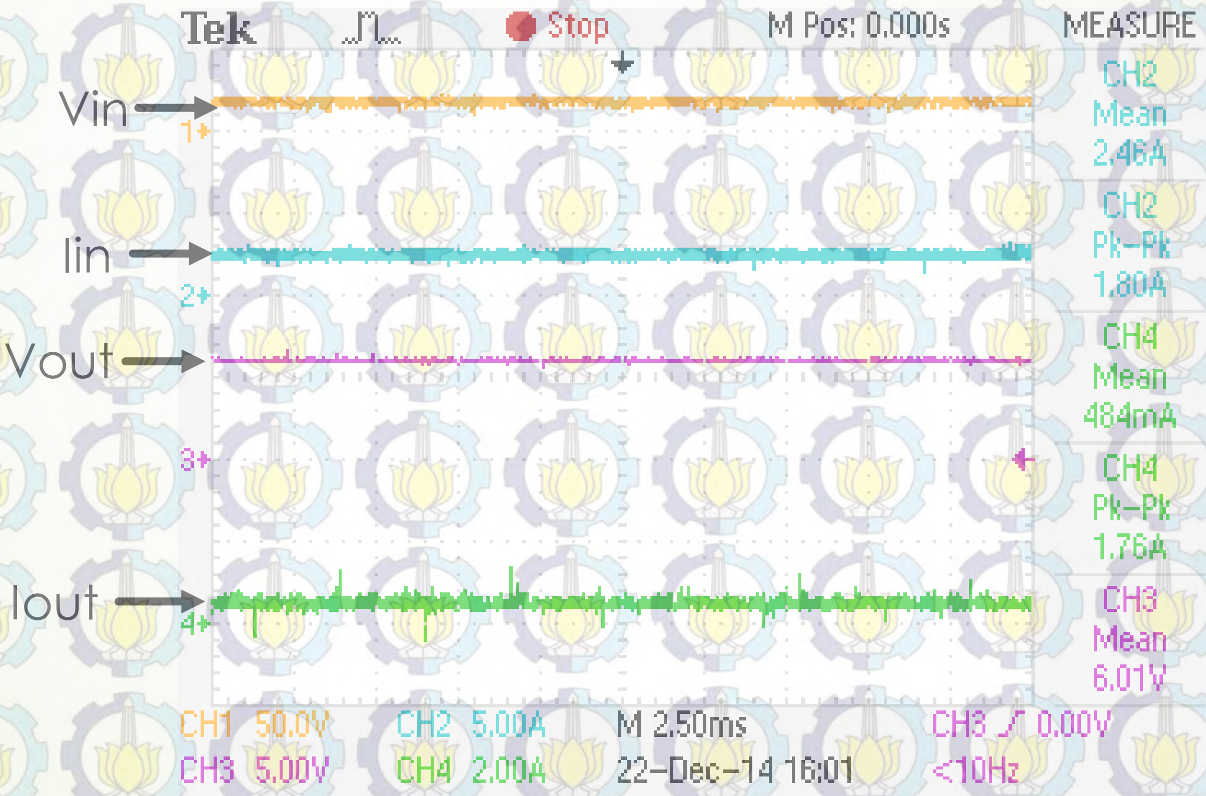
Pengujian Perubahan Beban

Interleaved Boost Converter

Vin (V)	Iin (A)	Vout (V)	Iout (mA)	Pin (W)	Pout (W)	Pout (%)	Efisiensi (%)
18.1	2.43	60.0	608	43.98	36.48	100	82.94
18.0	2.16	60.0	541	38.88	32.46	90	83.49
18.1	1.88	60.0	477	34.03	28.62	80	84.11
18.0	1.65	60.1	427	29.70	25.66	70	86.41
18.1	1.38	59.9	363	24.98	21.74	60	87.05
18.0	1.13	60.1	297	20.34	17.85	50	87.76
18.0	0.92	60.1	240	16.49	14.42	40	87.48



Gelombang Arus dan Tegangan Interleaved Boost Converter (P=100%)



Pengujian Perubahan Duty Cycle

Tujuan:

- Mengetahui error tegangan yang dihasilkan masing-masing konverter
- Mengetahui rasio konversi tegangan yang dihasilkan masing-masing konverter

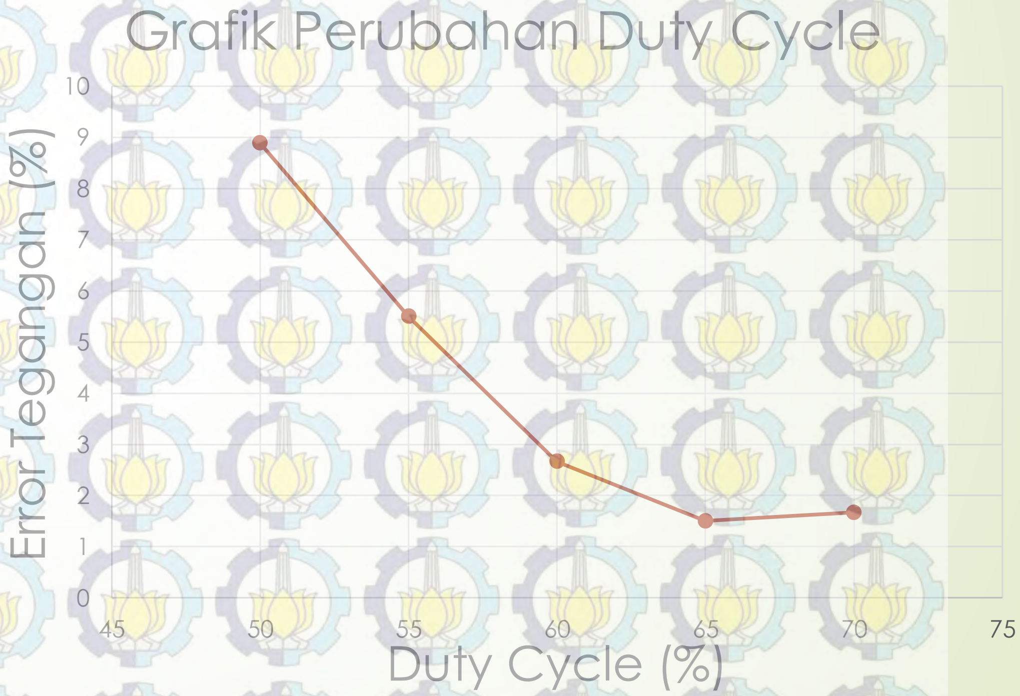
Parameter

- R = 100Ω

Pengujian Perubahan Duty Cycle

Boost Converter Konvensional

D (%)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Vout Teori	Error (%)
50	18	1.02	39.2	0.425	36	8.89
55	18	1.19	42.2	0.477	40	5.5
60	18	1.41	46.2	0.52	45	2.67
65	18	1.78	52.2	0.582	51.43	1.5
70	18	2.47	59	0.619	60	1.67



Pengujian Perubahan Duty Cycle

Interleaved Boost Converter

D (%)	Vin (V)	Iin (A)	Vout (V)	Iout (A)	Vout Teori	Error (%)
50	18	0.878	38.2	0.413	36	6.11
55	18	1.05	41.9	0.443	40	4.75
60	18	1.3	46.2	0.469	45	2.667
65	18	1.74	52.3	0.53	51.43	1.69
70	18	2.247	60.5	0.622	60	0.83

Kesimpulan

- Ripple arus input Interleaved Boost Converter lebih kecil dibandingkan Boost Converter konvensional

  ΔIin IBC = 1.80A, ΔIin conv. = 4.20A

- Ripple arus output Interleaved Boost Converter lebih kecil dibandingkan Boost Converter konvensional

  ΔIout IBC = 1.76A, ΔIout conv. = 2.6A

- Efisiensi Interleaved Boost Converter lebih tinggi dibandingkan Boost Converter konvensional

  η IBC = 87.76%, η conv = 84.33

Kesimpulan

- Error tegangan IBC lebih kecil dibandingkan dengan Boost Converter konvensional

  Verror IBC = 6.11%, Verror conv. = 8.89%

- Rasio konversi tegangan IBC lebih tinggi dibandingkan dengan Boost Converter Konvensional

  M IBC = 60.5V @ DC = 70%, M conv. = 59V @ DC = 70%,

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Terima kasih

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Daftar Pustaka

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