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Lampiran A. Hasil uji karakteristik modul Termoelektrik

Tabel 4. Hasil uji karakteristik TEG tipe TEC1-12706 dan SP1848-27145 SA menggunakan beban, R = 15,32 Ohm

Th (K)	ΔT(K)	TEC1-12706				SP 1848-12745 SA			
		q_a	q_e	%Aa	%Ae	q_a	q_e	%Aa	%Ae
307,2	4					0,954	0,954	1,56%	1,59%
315,3	10					2,211	2,212	3,53%	3,65%
323,8	15	8,55	8,53	4,9%	5,1%				
330,5	20	11,96	11,89	6,7%	7,1%				
331,3	21					4,644	4,647	7,06%	7,56%
337,5	25	15,49	15,37	8,5%	9,2%				
338,1	26					5,598	5,602	8,34%	9,04%
353,2	30	21,83	21,60	11,5%	12,6%				
345,3	31					6,604	6,610	9,64%	10,59%
352,5	35					7,594	7,601	10,86%	12,08%
359,8	35	24,04	23,76	12,4%	13,8%				
359,3	39					8,474	8,481	11,88%	13,36%
371,4	41	28,68	28,27	14,4%	16,2%				
379,2	46	31,28	30,79	15,3%	17,4%				
370,4	46					9,934	9,942	13,52%	15,47%
374,0	49					10,419	10,429	14,04%	16,16%
386,1	50	33,96	33,38	16,4%	18,7%				
384,0	54					11,572	11,583	15,19%	17,70%
393,4	55	36,59	35,95	17,3%	20,0%				

Tabel 5. Perbandingan tegangan U (teoritis) dan V percobaan pada sel TEC1-12706 dan sel SP1848-27145SA yang diposisikan sebagai pembangkit TEG

ΔT(K)	Tegangan TEC1-12706		SP1848-27145SA	
	V percobaan (Volt)	U teoritis (Volt)	V percobaan (volt)	U teoritis (volt)
15,02	0,07	0,76		
16,58			0,76	0,20
18,94			0,82	0,23
20,08	0,19	1,02		
21,40			0,88	0,26
23,69			0,93	0,28
25,22	0,29	1,28		
25,97			0,98	0,31
28,25			1,03	0,34
30,58			1,08	0,37
33,03			1,13	0,40
35,30			1,18	0,42
35,41	0,38	1,80		
37,64			1,22	0,45
39,46			1,26	0,47

Tabel 5 (Lanjutan)

ΔT(K)	Tegangan TEC1-12706		SP1848-27145SA	
	V percobaan (Volt)	U teoritis (Volt)	V percobaan (volt)	U teoritis (volt)
40,59	0,44	2,06		
41,74			1,31	0,50
43,74			1,34	0,53
45,98	0,54	2,33		
46,50			1,38	0,56
48,68			1,41	0,58
49,95	0,59	2,53		
50,58			1,45	0,61
52,37			1,47	0,63
54,16			1,50	0,65
54,96	0,69	2,79		
55,50			1,51	0,67

Tabel 6. Perbandingan TEC TEC1-12706 dan SP1848-27145 berdasarkan I,V, dan P terhadap beda temperatur yang diberikan.

ΔT (K)	TEC1-12706			SP 1848-27145		
	V (volt)	I (Ampere)	P (Watt)	V (volt)	I (Ampere)	P (Watt)
0,65				0,01	0,00	0,00
1,76				0,16	0,00	0,00
4,25				0,33	0,03	0,01
8,09				0,48	0,05	0,02
12,20				0,63	0,07	0,04
13,75	0,04	0,02	0,00			
14,45				0,69	0,08	0,06
16,46	0,04	0,02	0,00			
18,12	0,15	0,06	0,01			
18,94				0,82	0,09	0,07
20,08	0,19	0,07	0,01			
22,43	0,24	0,09	0,02			
23,91	0,26	0,10	0,03			
25,97	0,29	0,11	0,03	0,98	0,11	0,11
28,25				1,03	0,12	0,12
30,58	0,35	0,13	0,0455	1,08	0,13	0,14
33,03				1,13	0,13	0,15
35,30				1,18	0,14	0,17
35,41	0,38	0,16	0,06			
36,27	0,40	0,16	0,06			
37,64				1,22	0,14	0,17
37,75	0,42	0,17	0,07			
39,05	0,41	0,17	0,07			
39,46				1,26	0,15	0,19
40,59	0,44	0,17	0,08			
41,74				1,31	0,15	0,20
42,42	0,49	0,19	0,09			

Tabel 6 (Lanjutan)

ΔT (K)	TEC1-12706			SP 1848-27145		
	V (volt)	I (Ampere)	P (Watt)	V (volt)	I (Ampere)	P (Watt)
43,74				1,34	0,16	0,21
44,20	0,50	0,20	0,10			
45,98	0,54	0,21	0,11			
46,50				1,38	0,16	0,22
47,47	0,53	0,21	0,11			
48,45	0,56	0,22	0,12			
48,68				1,41	0,17	0,24
49,95	0,59	0,23	0,14			
50,58				1,45	0,17	0,25
51,04	0,64	0,25	0,16			
51,09	0,67	0,27	0,18			
52,37				1,47	0,17	0,25

Lampiran B. Parameter perhitungan efisiensi energi kompor tanpa TEG dengan metode *boiling water methode*

Tabel 7. Parameter perhitungan efisiensi energi kompor tanpa TEG dengan metode *boiling water methode*

Massa bahan bakar (kg)			Suhu air, (℃)			Massa air, m_v (kg)		
m_{awal}	m_{akhir}	Δm_k	Ti	Tb	ΔT	m_{v1}	m_{v2}	Δm_v
1	2	3=1-2	4	5	6=5-4	7	8	9=7-8
0,25	0,03	0,22	26,78	86,94	60,16	1	0,86	0,14

Tabel 7 di atas merupakan tabel catatan parameter yang diperlukan dalam percobaan. Tabel ini berisikan keteratangan tentang jumlah massa bahan bakar, suhu air, dan massa air yang dipanaskan oleh kompor hingga mendidih. Pengolahan data dilakukan dengan melakukan identifikasi energi termal pembakaran dalam kompor.

m_{v1} (massa awal air)	1 kg
Cp (air)	4,180 kJ/kg ℃
Δm_v (massa air menguap)	0,14 kg
H_v (kalor laten air)	2.256,4 kJ/kg
H_c (nilai kalor bahan bakar)	17.994.866 J/kg
Δm_k (massa bahan bakar yang terbakar)	0,22 kg
ΔT_{air}	60,16 ℃

maka nilai efisiensi termal (η_T) kompor dapat diketahui melalui persamaan (3.3) sebagai berikut (Montecucco *et al.*, 2015);

$$\eta_T = \frac{E_{out}}{E_{in}} x\ 100\% = \frac{m_a\ Cp\ \Delta T + \Delta m_v\ H_v}{\Delta m_k H_c}\ x\ 100\% = 14{,}34\ \%$$

Lampiran C. Hasil pengujian nilai kalor dari pelet kayu yang digunakan sebagai bahan bakar dalam penelitian ini

F 413.3

Laboratorium Pengujian tekMIRA

PUSAT PENELITIAN DAN PENGEMBANGAN TEKNOLOGI MINERAL DAN BATUBARA

Jl. Jenderal Sudirman 623 Bandung - 40211

Telepon : (022) 6030483 Faksimile : (022) 6003373 e- mail : lab_uji@tekMIRA.esdm.go.id

SERTIFIKAT ANALISIS

(CERTIFICATE OF ANALYSIS)

Nomor / *Number* : 1067/LBB/IX/2018 Tanggal / *Date* : 14 September 2018

Dibuat untuk / *Certified for*	:	M. Zuhud Andrya
Jenis contoh / *Type of Sample*	:	Pellet Kayu
Sifat / Kondisi Barang yang diuji / *Description of sample*	:	-
Asal contoh *Origin of sample*	:	-
Jumlah contoh / *Amount of sample*	:	1 (satu)
Nomor Laboratorium / *Laboratory Number*	:	5112/2018
Contoh diterima tanggal / *Sample received on*	:	12 September 2018
Waktu pelaksanaan pengujian / *Date of testing*	:	12 September 2018

HASIL ANALISIS / ANALYSIS RESULT :

ANALYSIS PARAMETERS	Sample Marks 5112/2018 Pellet Kayu	Unit	Basis
GROSS CALORIFIC VALUE	4.298	cal/g	adb

Laboratorium Batubara,

Astuti Rahayu, S.Si

NIP. 19730923 199403 2 002

Catatan : 1. Hasil pengujian/analisis ini hanya berlaku untuk contoh yang diuji

Notes The analysis result are valid only for the tested samples

2. Sertifikat ini tidak boleh diperbanyak (digandakan) tanpa izin dari Manajer Teknis

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Lampiran D. Data Hasil Percobaan Pemasangan 2 unit TEG

Tabel 8. Data hasil percobaan pemasangan 2 unit TEG secara seri di titik1.

Waktu (mnt)	Waktu (Dtk)	Tc, (K)	T_{air}, (K)	T_H, (K)	ΔT (K)	I (amp)	V (volt)	P (watt)	W*dtk (joule)
1	2	3	4	5	6	7	8	9	10
1	60	298	298,50	309,66	11,75	0,010	0,190	0,002	0,114
2	120	298	300,66	314,30	15,93	0,010	0,200	0,002	0,120
3	180	299	305,87	322,47	23,33	0,020	0,300	0,006	0,360
4	240	300	308,52	336,83	36,38	0,030	0,400	0,012	0,720
5	300	302	312,52	353,44	51,05	0,040	0,580	0,023	1,392
6	360	305	317,44	372,32	67,55	0,050	0,790	0,040	2,370
7	420	308	322,10	386,77	79,06	0,060	0,980	0,059	3,528
8	480	311	327,11	394,76	84,15	0,086	1,140	0,098	5,882
9	540	314	330,97	403,28	89,65	0,094	1,480	0,139	8,347
10	600	317	335,90	406,66	90,14	0,096	1,490	0,143	8,582
11	660	319	342,12	411,42	92,04	0,098	1,520	0,149	8,938
12	720	322	347,20	412,87	90,61	0,097	1,490	0,145	8,672
13	780	325	350,21	413,96	88,96	0,093	1,480	0,138	8,258
14	840	328	354,44	414,26	86,72	0,092	1,460	0,134	8,059
15	900	330	360,46	414,20	83,89	0,089	1,430	0,127	7,636
16	960	333	364,27	418,29	85,14	0,092	1,446	0,133	7,982
17	1020	335	368,83	418,15	83,43	0,089	1,430	0,127	7,636
18	1080	337	369,73	418,15	81,05	0,087	1,423	0,124	7,428
19	1140	339	369,65	418,15	79,00	0,084	1,410	0,118	7,106
20	1200	340	370,15	418,15	77,71	0,083	1,390	0,115	6,922
21	1260	342	370,15	418,15	76,39	0,081	1,380	0,112	6,707
22	1320	343	369,84	418,64	75,52	0,080	1,360	0,109	6,528
23	1380	344	369,79	418,15	73,94	0,079	1,350	0,107	6,399
24	1440	345	369,88	400,96	55,80	0,069	1,214	0,084	5,026
25	1500	344	369,61	389,98	45,72	0,061	1,011	0,062	3,700
26	1560	344	369,65	379,27	35,48	0,053	0,900	0,048	2,862
27	1620	343	369,51	370,03	27,52	0,048	0,730	0,035	2,102
28	1680	341	369,39	361,86	20,80	0,038	0,600	0,023	1,368
29	1740	340	369,15	354,91	15,35	0,029	0,490	0,014	0,853
30	1800	338	368,03	349,44	11,92	0,025	0,370	0,009	0,555
31	1860	336	367,24	345,11	9,12	0,020	0,330	0,007	0,396
32	1920	334	366,94	342,12	7,74	0,018	0,300	0,005	0,324
33	1980	333	367,09	339,28	6,71	0,016	0,270	0,004	0,259
34	2040	331	366,62	336,35	5,17	0,014	0,250	0,004	0,210
35	2100	330	366,47	333,68	4,09	0,012	0,220	0,003	0,158
36	2160	328	366,45	331,94	3,80	0,010	0,210	0,002	0,126

Tabel 8 (Lanjutan)

Waktu (mnt)	Waktu (Dtk)	Tc, (K)	T_{air}, (K)	T_H, (K)	ΔT (K)	I (amp)	V (volt)	P (watt)	W*dtk (joule)
37	2220	327	366,24	330,79	4,03	0,010	0,190	0,002	0,115
38	2280	325	366,30	329,71	4,32	0,010	0,190	0,002	0,114
39	2340	324	366,26	327,99	3,80	0,009	0,180	0,002	0,097
40	2400	323	366,10	326,39	3,40	0,008	0,170	0,001	0,082
41	2460	322	365,91	325,39	3,52	0,009	0,170	0,001	0,087
42	2520	321	365,82	324,90	3,99	0,011	0,170	0,002	0,112
43	2580	320	365,73	324,64	4,80	0,012	0,160	0,002	0,115
44	2640	319	365,64	324,32	5,32	0,013	0,160	0,002	0,125
45	2700	318	365,41	322,88	4,69	0,011	0,160	0,002	0,108
46	2760	317	365,16	321,93	4,58	0,011	0,150	0,002	0,101
47	2820	316	364,96	321,55	5,15	0,013	0,150	0,002	0,117
48	2880	316	364,86	320,41	4,75	0,011	0,140	0,002	0,096
49	2940	315	364,48	319,68	4,63	0,011	0,140	0,002	0,095
50	3000	314	364,41	318,63	4,23	0,013	0,130	0,002	0,101
51	3060	314	364,14	318,00	4,17	0,010	0,130	0,001	0,078
52	3120	313	363,86	316,80	3,53	0,009	0,120	0,001	0,065
53	3180	313	363,54	316,30	3,65	0,009	0,110	0,001	0,061
54	3240	312	363,34	315,18	3,19	0,008	0,100	0,001	0,049
55	3300	311	362,80	314,28	2,79	0,008	0,100	0,001	0,047
56	3360	311	362,59	313,54	2,68	0,008	0,100	0,001	0,046
57	3420	310	361,92	312,81	2,56	0,007	0,090	0,001	0,040
58	3480	310	361,66	311,97	2,21	0,007	0,080	0,001	0,035
59	3540	309	361,48	311,37	2,15	0,007	0,080	0,001	0,034
60	3600	309	361,01	310,78	2,10	0,007	0,080	0,001	0,033
61	3660	308	360,50	310,26	1,92	0,007	0,080	0,001	0,031
62	3720	308	360,23	309,76	1,92	0,007	0,070	0,000	0,027
63	3780	307	360,00	309,40	1,92	0,007	0,070	0,000	0,027
64	3840	307	359,62	309,08	1,92	0,007	0,070	0,000	0,027

140,202

Tabel 9. Parameter perhitungan efisiensi energi termal kompor

Massa bahan bakar (kg)			Suhu air, T_{air} (℃)			Massa air, m_v (kg)			Energi, E_{out} listrik (J)
m_{awal}	m_{akhir}	Δm_k	Ti	Tb	ΔT	m_{v1}	m_{v2}	Δm_v	
1	2	3=1-2	4	5	6=5-1	7	8	9=7-8	10
0,40	0,055	0,345	25	96	71	2	1,88	0,12	140,2

Melalui persamaan (3.1) energi termal yang dihasilkan dari pembakaran bahan bakar biomassa pelet kayu yang digunakan selama waktu 64 menit adalah sebagai berikut:

$$\mathrm{E_{in}} = \Delta m_k H_c = 6.208.228{,}91\ Joule \tag{3.3}$$

Sebagian energi (E_{in}) tersebut diserap oleh 2 liter air di dalam panci untuk mendidih. Jumlah energi yang terserap (E_{out}) tersebut dihitung berdasarkan Persamaan (3.2) sebagai berikut :

$$E_{out\ termal} = m_a\ Cp\ \Delta T + \Delta m_v H_v = 864.328\ Joule \tag{3.2}$$

Apabila diasumsikan TEG tidak terpasang pada percobaan ini, maka nilai efisiensi termal (η_T) dapat dihitung melalui Persamaan (3.3), sebagai berikut:

$$\eta_T = \frac{E_{out}}{E_{in}} x\ 100\% = \frac{864.328}{6.208.228{,}91}\ x\ 100\% = 13{,}922\ \% \tag{4.4}$$

Lampiran E. Spesifikasi Baterai Jenis Lithium-ion

Tabel 10. Perbandingan Jenis Baterai Tipe Lithium-ion

N	Nama	Nama lain	Penggunaan	Tegangan	Coments
1	Lithium Cobalt Oxide ($LiCoO_2$)	LCO / Li-cobalt	mobile phones, laptops, and digital cameras	Nominal 3,6 V typical operating range 3,0-4,2 V/cell	Very high specific energy, limited specific power. Cobalt is expensive. Serves as Energy Cell. Market share has stabilized.
2	Lithium Manganese Oxide (LiMn2O4)	LMO / Li-manganese (spinel structure)	Power tools, medical devices, electric powertrain	Nominal 3,7V (3,8V); typical operating range 3,0-4,2V/cell	High power but less capacity; safer than Li-cobalt; commonly mixed with NMC to improve performance.
4	Lithium Nickel Manganese Cobalt Oxide ($LiNiMnCoO_2$ or NMC)	NMC (NCM, CMN, CNM, MNC, MCN)	E-bikes, medical devices, EVs, Industrial	Nominal 3,6V (3,7V); typical operating range 3,0-4,2V/cell, or higher	Provides high capacity and high power. Serves as Hybrid Cell. Favorite chemistry for many uses; market share is increasing.
5	Lithium Iron Phosphate $LiFePO_4$)	LFP / Li-phosphate	Portable and stationary needing high load currents and endurance	Nominal 3,2V, 3,3V; typl operating range 2,5–3,65V/cell	Portable and stationary needing high load currents and endurance
6	Lithium Nickel Cobalt Aluminum Oxide ($LiNiCoAlO_2$)	NCA / Li-aluminum	Medical devices, Industrial, electric powertrain (Tesla)	Nominal 3,6V; typical operating range 3,0–4,2V/cell	Shares similarities with Li-cobalt. Serves as Energy Cell.
7	Lithium Titanate ($Li_4Ti_5O_{12}$)	LTO / Li-titanate	UPS, electric powertrain (Mitsubishi i-MiEV, Honda Fit EV), solar-powered street lighting	Nominal 2,4V; typical operating range 1,8–2,85V/cell	Long life, fast charge, wide temperature range but low specific energy and expensive. Among safest Li-ion batteries.

Sumber : (Bunchmann, 2018)

Lampiran F. Metode perhitungan desain pengatur tegangan dc tipe *Buck-Boost converter*

Diketahui :

Jika tegangan sumber yang digunakan sebagai basis desain adalah Vs = 1,2 Volt, dan tegangan output diatur agar stabil pada Vo = 4,2 Volt dan Arus Io = 0,2 A maka R dicari dengan ;

$$R = \frac{Vo}{Io} = \frac{4{,}2}{0{,}2} = 21\ \Omega$$

$$D = 1 - \frac{Vs}{Vo} = 1 - \frac{1{,}2}{4{,}2} = 0{,}71$$

D dalam derajat = 0,71 x 360° = 257,14°

Dengan menggunakan frequensi f = 25.000 Hz, maka nilai L minimum dapat dihitung dengan;

$$L_{min} = \frac{D\ (1-D)^2\ R}{2\ f} = \frac{0{,}71\ (1-0{,}71)^2\ 21}{2\ x\ 25.000} = 24\ \mu H$$

Jika diinginkan agar ripple tegangan di bawah 1%, maka Capasitor minimum yang dapat digunakan dihitung dengan;

$$C_{min} = \frac{D}{R\ (\Delta Vo/Vo)\ f} = \frac{0{,}71}{21\ x\ 0{,}01\ x\ 25.000} = 136\ \mu F$$

Dengan nilai-nilai komponen yang telah diketahui, maka topologi buck-boost converter disimulasikan dengan menggunakan perangkat lunak PSIM, sehingga membentuk topologi sbb;

Tabel 11. Parameter elektris dari konfigurasi 12 unit TEG yang dipasang seri dan paralel pada kompor menggunakan topologi *boost-converter*

menit	Terhubung langsung				Pengatur Tegangan digunakan						
	Vs (volt)	I (amp)	P (watt)	W*s (joule)	Duty cycle(°)	L (µH)	C (µF)	Vo (volt)	I (amp)	P (watt)	W*s (joule)
1	0,57	0,020	0,011	0,68	317,0	550	500	4,15	0,003	0,011	0,65
2	0,60	0,020	0,012	0,72	315,0	550	500	4,20	0,003	0,011	0,68
3	0,90	0,040	0,036	2,16	296,5	550	500	4,20	0,008	0,034	2,05
4	1,20	0,060	0,072	4,32	280,0	550	500	4,20	0,016	0,068	4,10
5	1,74	0,080	0,139	8,35	254,5	550	500	4,20	0,032	0,132	7,93
6	2,37	0,100	0,237	14,22	230,0	550	500	4,19	0,054	0,225	13,51
7	2,94	0,120	0,353	21,17	211,5	550	500	4,19	0,080	0,335	20,11
8	3,42	0,172	0,588	**35,29**	198,0	550	500	4,18	0,134	0,559	33,53
9	4,44	0,188	0,835	50,08	175,0	550	500	4,20	0,189	0,793	47,58
10	4,47	0,192	0,858	51,49	174,0	550	500	4,18	0,195	0,815	48,92
11	4,56	0,196	0,894	53,63	174,0	550	500	4,19	0,202	0,849	50,94
12	4,47	0,194	0,867	52,03	174,0	550	500	4,18	0,197	0,824	49,43
13	4,44	0,186	0,826	49,55	175,0	550	500	4,20	0,187	0,785	47,07
14	4,38	0,184	0,806	48,36	176,0	550	500	4,19	0,183	0,766	45,94
15	4,29	0,178	0,764	45,82	178,0	550	500	4,20	0,173	0,725	43,53
16	4,34	0,184	0,798	47,89	177,0	550	500	4,20	0,181	0,758	45,50
17	4,29	0,178	0,764	45,82	178,0	550	500	4,20	0,173	0,725	43,53
18	4,27	0,174	0,743	44,57	178,0	550	500	4,18	0,169	0,706	42,34
19	4,23	0,168	0,711	42,64	179,0	550	500	4,18	0,162	0,675	40,51
20	4,17	0,166	0,692	**41,53**	180,5	550	500	4,19	0,157	0,658	39,46
21	4,14	0,162	0,671	**40,24**	181,0	550	500	4,19	0,152	0,637	38,23
22	4,08	0,160	0,653	**39,17**	182,0	550	500	4,20	0,148	0,620	37,21
23	4,05	0,158	0,640	**38,39**	183,0	550	500	4,19	0,145	0,608	36,47
24	3,64	0,138	0,503	**30,16**	192,8	550	500	4,19	0,114	0,477	28,65
25	3,03	0,122	0,370	**22,20**	209,0	550	500	4,20	0,084	0,352	21,09
26	2,70	0,106	0,286	17,17	219,0	550	500	4,19	0,065	0,272	16,31
27	2,19	0,096	0,210	12,61	236,5	550	500	4,20	0,048	0,200	11,98
28	1,80	0,076	0,137	8,21	252,0	550	500	4,20	0,031	0,130	7,80
29	1,47	0,058	0,085	5,12	266,5	550	500	4,19	0,019	0,081	4,86
30	1,11	0,050	0,056	3,33	284,5	550	500	4,18	0,013	0,053	3,16
31	0,99	0,040	0,040	2,38	291,0	550	500	4,18	0,009	0,038	2,26
32	0,90	0,036	0,032	1,94	296,5	550	500	4,20	0,007	0,031	1,85
33	0,81	0,032	0,026	1,56	301,5	550	500	4,18	0,006	0,025	1,48
34	0,75	0,028	0,021	1,26	305,4	550	500	4,20	0,005	0,020	1,20
35	0,66	0,024	0,016	0,95	311,0	550	500	4,18	0,004	0,015	0,90
36	0,63	0,020	0,013	0,76	313,0	550	500	4,19	0,003	0,012	0,72
37	0,57	0,020	0,012	0,69	317,0	550	500	4,20	0,003	0,011	0,66
38	0,57	0,020	0,011	0,68	317,0	550	500	4,20	0,003	0,011	0,65
39	0,54	0,018	0,010	0,58	318,9	550	500	4,19	0,002	0,009	0,55
40	0,51	0,016	0,008	0,49	321,0	550	500	4,19	0,002	0,008	0,47
41	0,51	0,017	0,009	0,52	321,0	550	500	4,19	0,002	0,008	0,49
42	0,51	0,022	0,011	0,67	321,0	550	500	4,19	0,003	0,011	0,64
43	0,48	0,024	0,012	0,69	323,0	550	500	4,19	0,003	0,011	0,66
44	0,48	0,026	0,012	0,75	323,0	550	500	4,19	0,003	0,012	0,71
45	0,48	0,023	0,011	0,65	323,0	550	500	4,19	0,002	0,010	0,62
46	0,45	0,022	0,010	0,60	324,0	550	500	4,05	0,002	0,010	0,57

Tabel 11 (Lanjutan)

menit	Terhubung langsung				Pengatur Tegangan digunakan						
	Vs (volt)	I (amp)	P (watt)	W*s (joule)	Duty cycle(°)	L (µH)	C (µF)	Vo (volt)	I (amp)	P (watt)	W*s (joule)
47	0,45	0,026	0,012	0,70	324,0	550	500	4,05	0,003	0,011	0,67
48	0,42	0,023	0,010	0,57	324,0	550	500	3,78	0,002	0,009	0,55
49	0,42	0,023	0,009	0,57	324,0	550	500	3,78	0,002	0,009	0,54
50	0,39	0,026	0,010	0,61	324,0	550	500	3,51	0,003	0,010	0,58
51	0,39	0,020	0,008	0,47	324,0	550	500	3,51	0,002	0,007	0,44
52	0,36	0,018	0,006	0,39	324,0	550	500	3,24	0,002	0,006	0,37
53	0,33	0,018	0,006	0,36	324,0	550	500	3,24	0,002	0,006	0,35
54	0,30	0,016	0,005	0,29	324,0	550	500	2,70	0,002	0,005	0,28
55	0,30	0,016	0,005	0,28	324,0	550	500	2,70	0,002	0,004	0,27
56	0,30	0,015	0,005	0,27	324,0	550	500	2,70	0,002	0,004	0,26
57	0,27	0,015	0,004	0,24	324,0	550	500	2,43	0,002	0,004	0,23
58	0,24	0,014	0,003	0,21	324,0	550	500	2,16	0,002	0,003	0,20
59	0,24	0,014	0,003	0,20	324,0	550	500	2,16	0,001	0,003	0,19
60	0,24	0,014	0,003	0,20	324,0	550	500	2,16	0,001	0,003	0,19
61	0,24	0,013	0,003	0,19	324,0	550	500	2,16	0,001	0,003	0,18
62	0,21	0,013	0,003	0,16	324,0	550	500	1,89	0,001	0,003	0,16
63	0,21	0,013	0,003	0,16	324,0	550	500	1,89	0,001	0,003	0,16
64	0,21	0,013	0,003	0,16	324,0	550	500	1,89	0,001	0,003	0,16
Total (W.s)				898,15							853,24
Terpakai (W.s)				778,86							850,99

Keterangan:

- Tanpa converter dc, tegangan output TEG yang mencapai tegangan kerja baterai Li-ion dicapai pada menit ke 6 s.d.24 (selama 18 menit).
- Dengan menggunakan converter dc (Efisiensi: 95%), peluang pengaturan tegangan pada tegangan kerja baterai Li-ion dicapai pada menit ke-1 s.d.53 (selama 53 menit).
- Maksimum Duty cycle adalah 324° (90% x 360°).

Peluang efisiensi pemanfaatan energi terbuang kompor melalui pemasangan 12 unit TEG, jika:

1). Terhubung langsung: 18 menit

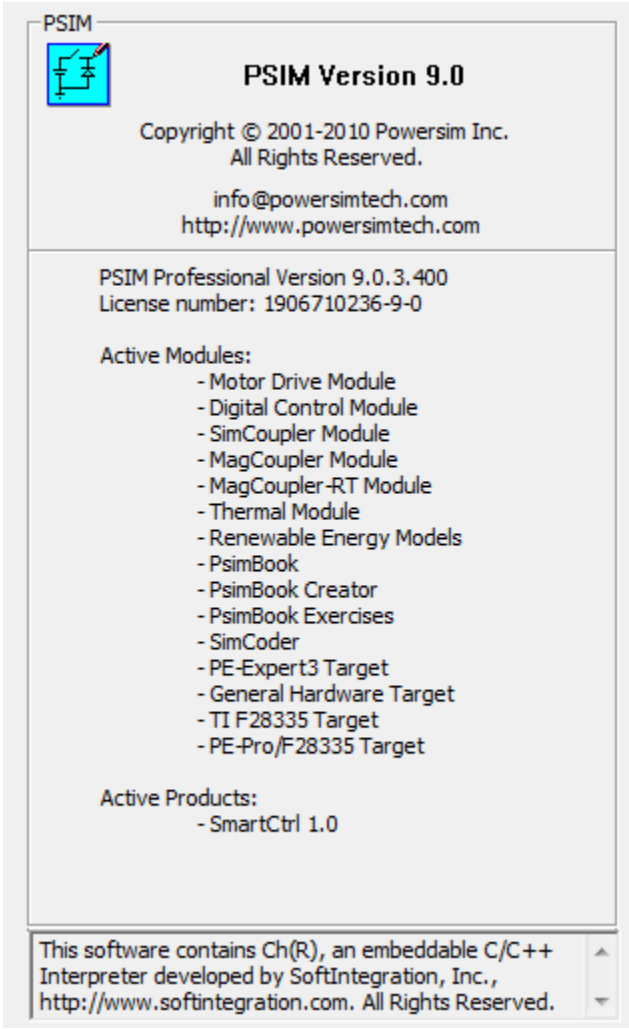
$$\eta = \frac{Energi\ termanfaatkan}{Energi\ bahan\ bakar} = \frac{E_{out\ air} + E_{out\ TEG}}{E_{input\ (termal)}}\ x\ 100\ \%$$

$$= \frac{864.328\ + 778{,}86}{6.208.228{,}91}\ x\ 100\ \% = 13{,}935\ \%$$

2). Menggunakan pengatur tegangan *buck-boost converter*: 53 menit

$$\eta\ = \frac{864.328\ +\ 850{,}99}{6.208.228{,}91}\ x\ 100\ \% = 13{,}936\ \%$$

Lampiran G. Spesifiasi Perangkat Lunak PSIM



Lampiran H. Spesifikasi teknis modul Termoelektrik TEC1-12706 dan SP1848-27145 SA

1. Spesifikasi teknis TEC1-12706

Hebei I.T. (Shanghai) Co., Ltd.

Thermoelectric Cooler

TEC1-12706

Performance Specifications

Hot Side Temperature (° C)	25° C	50° C
Qmax (Watts)	50	57
Delta Tmax (° C)	66	75
Imax (Amps)	6.4	6.4
Vmax (Volts)	14.4	16.4
Module Resistance (Ohms)	1.98	2.30

Sumber : Hebei

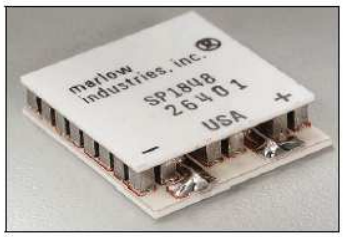
2. Spesifikasi teknis SP 1848-27145 SA

marlow Industries Inc.®

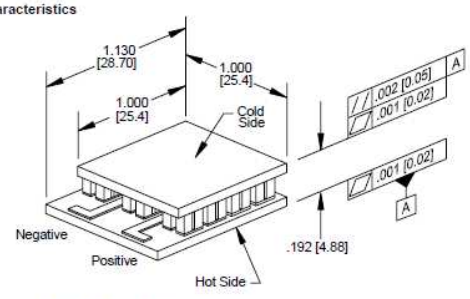
Thermoelectric Cooler **SP1848**

Performance Values

Hot Side Temperature (°C)	27°C	50°C
Δ Tmax (°C-dry N_2):	62.0	70.6
Qmax (watts):	21.3	23.6
Imax (amps):	9.36	9.24
Vmax (vdc):	3.48	3.88
AC Resistance (ohms):	0.323	---



Mechanical Characteristics

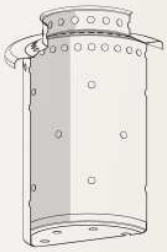


Ceramic Material: Alumina (AC)
Millimeters are in [ ]

Lampiran I. Spesifikasi Teknis Kompor

(Sumber : Primestoves.com)

PRODUCT NO: 10007
PRIME SQUARE FUELWOOD REGULAR



SPECIFICATIONS:

MATERIALS:	Stainless steel, galvanized iron plat, heat proof powder coating
DIMENSIONS:	28 cm x 28 cm x 36 cm
WEIGHT:	3.5 kg
FIREPOWER:	Up to 6,000 Watts
FUEL CAPACITY:	0.3-2 kg
BURN TIME:	0.5-2 hours depending on fuel loading
SIZE:	Regular (for households of 4-6 members)
QUANTITY IN 20' CONTAINER:	1,050 units

FUELS:

- Fuelwood
- Woodchips
- Briquettes
- Coconut husk
- Corncobs
- Other bulky biomass

STOVE PERFORMANCE [1]

PARAMETER	PRIME	BASELINE	IMPROVEMENT
SYSTEM EFFICIENCY (%)	26.3	16	64%
CO EMISSIONS (g/MJ)	5.5	18	-69%
PM EMISSIONS (mg/MJ)	30	550	-95%

[1] Testing conducted for the Clean Stove Initiative Indonesia by the World Bank in 2014.

Lampiran J. Sertifikat Uji Kompor Primestove Fuulwood Regular No. 10007

(Sumber: Primestoves.com)

YAYASAN **DIAN - DESA**

Kelompok Pengembangan Teknologi Tepat Guna
Appropriate Technology Group

Jl. Kaliurang Km. 7, Jurugsari IV/19 , P.O. Box 19, Bulaksumur , Yogyakarta , Indonesia

Yayasan Dian Desa Lab Yogyakarta, Indonesia	Consolidated Test Report	Rev 1	Page 1 of 1
		Document YDDL-02	
Author: Prianti Utami	Approved: Crispin P Piggot	Date: 2014-11-01	

APPLICANT

Product type	Cooking stove
Manufacturer	Prime Square
Model/Name	PSB1 Wood
Batch number	-
Serial number	-
Reference drawings	-

PRODUCT INFORMATION

Name	Yayasan Kopernik
Address	PO Box 1902, Ubud Bali
Contact person	Ewa Wojkowska
Email address	ewa.wojkowska@kopernik.info
Phone	+62 812 37030424

TEST	PROTOCOL VERSION	
X	Indonesia National Standard (SNI) No. 7926-2013	SNI 2014
X	CSI Water Heating Test, Technical Test	CSI-WHT TT 1.0
	CSI Water Heating Test, Cooking Test	CSI-WHT CT 1.0
	CSI Water Boiler Test	CSI-WBT B1.0
X	CSI Safety Evaluation	CSI-S1.0
X	CSI Durability Evaluation	CSI-D1.0

PRODUCT TYPE				FUEL			
Cooking	X	Water Boiler		No. of Pots	1	Fuel Type	Tectona grandis

RESULTS 1 – PRE-QUALIFICATION	PASS/FAIL	COMMENT
The product matches the drawings	Pass	
No obvious defects	Pass	
SNI Performance metrics	Pass	
CSI Safety Assessment	Pass	
CSI Durability Assessment	Pass	

RESULTS 2 – CSI Metrics			STAR RATING
System Efficiency	26.3	%	*
Particulate Matter $PM_{2.5}$	30	mg/MJ_{NET}	***
Carbon Monoxide	5.5	g/MJ_{NET}	***

Note: Additional testing information may be obtained by contacting YDD Lab Testing specialist at priantiutami@gmail.com

Date: 4 November 2014

Christina Aristanti
YDD Lab Manager

Lampiran K. Spesifikasi Teknis Modul Data Logger tipe USB-4718

USB-4718

8-Ch Thermocouple Input USB Module with 8-Ch Isolated Digital Input

Features

- Supports USB 2.0
- Supports voltage, current, and thermocouple inputs
- Bus powered
- 8 x Thermocouple input channels
- 2,500 V_{DC} isolation
- Supports 4 ~ 20 mA current input
- Detachable screw terminal on modules
- 8-ch isolated digital input and 8-ch isolated digital output
- Suitable for DIN rail mounting
- 1 x Lockable USB cable included for connection security

FCC CE

Introduction

The USB-4700 series comprises plug-and-play DAQ modules that can be installed without opening the chassis; simply plug in the modules to access collected data. Reliable and rugged enough for industrial applications, yet sufficiently affordable for home systems, USB-4700 series modules provide an easy and efficient means of adding measurement and control capabilities to USB-capable computers.

USB-4718 offers 8 thermocouple inputs with 16-bit resolution and up to 0.1% input range accuracy. With its compact and portable design, USB-4718 is ideal for field-based applications. Additionally, the module's input channels can be individually configured to enable handling of multiple sensor types.

Specifications

Analog Input

- **Accuracy** ±0.1% for voltage input
- **Bandwidth** 13.1 Hz @ 50 Hz, 15.72 Hz @ 60 Hz
- **Channels** 8 differential
- **Independent Channel Configuration** Yes
- **CMR @ 50/60 Hz** 92 dB min.
- **Resolution** 16 bits
- **Input Impedance** 1.8 MΩ
- **Input Range** 0 ~ 15 mV, 0 ~ 50 mV, 0 ~ 100 mV, 0 ~ 500 mV, 0 ~ 1 V, 0 ~ 2.5 V, 0 ~ 20 mA, 4 ~ 20 mA
- **Input Types** Thermocouple, mV, V, mA
- **Sampling Rate** 10 S/s (shared for all channels)

Note: Because of the hardware design, the sampling rate for each channel is fixed at 10/8 = 1.25 S/s per channel regardless of the number of channels used.

- **Span Drift** ±25 ppm/°C
- **T/C Type and Temperature Ranges**

J	0 ~ 760 °C	R	500 ~ 1750 °C
K	0 ~ 1370 °C	S	500 ~ 1750 °C
T	-100 ~ 400 °C	B	500 ~ 1800 °C
E	0 ~ 1000 °C		

- **TVS/ESD Protection** Built in
- **Zero Drift** ±0.3 μV/°C

Isolated Digital Input

- **Channels** 8
- **Input Voltage** Logic 0: 3 V max. Logic 1: 5 V min. (30 V max.)
- **Isolation Protection** 2,500 V_{DC}
- **Opto-Isolator Response** 25 μs

Isolated Digital Output

- **Channels** 8
- **Output Type** Sink (NPN)
- **Isolation Protection** 2,500 V_{DC}
- **Output Voltage** 5 ~ 30 V_{DC}, 1.1 A max./ total
- **Sink Current** 200 mA max./channel
- **Opto-Isolator Response** 25 μs

General

- **Bus Type** USB 2.0
- **I/O Connector** Onboard screw terminal
- **Dimensions (Lx W x H)** 132 x 80 x 32 mm (5.2" x 3.15" x 1.26")
- **Power Consumption** 100 mA @ 5 V
- **Watchdog Timer** 1.6 sec. (system)
- **Operating Temperature** 0 ~ 60 °C (32 ~ 140 °F)
- **Storage Temperature** -20 ~ 70 °C (-4 ~ 158 °F)
- **Storage Humidity** 5 ~ 95% RH non-condensing

Ordering Information

- **USB-4718-AE** 8-ch thermocouple input USB module

Accessories

- **1960004544** Wall mount bracket
- **1960005788** VESA mount bracket

Last updated: 13-Sep-2017

Sumber: PT. Advantech International

Lampiran L. Tabel Properti untuk Air Saturasi

Saturated water—Temperature table

		Specific volume, m^3/kg		Internal energy, kJ/kg			Enthalpy, kJ/kg			Entropy, kJ/kg·K		
Temp., T °C	Sat. press., P_{sat} kPa	Sat. liquid, v_f	Sat. vapor, v_g	Sat. liquid, u_f	Evap., u_{fg}	Sat. vapor, u_g	Sat. liquid, h_f	Evap., h_{fg}	Sat. vapor, h_g	Sat. liquid, s_f	Evap., s_{fg}	Sat. vapor, s_g
0.01	0.6117	0.001000	206.00	0.000	2374.9	2374.9	0.001	2500.9	2500.9	0.0000	9.1556	9.1556
5	0.8725	0.001000	147.03	21.019	2360.8	2381.8	21.020	2489.1	2510.1	0.0763	8.9487	9.0249
10	1.2281	0.001000	106.32	42.020	2346.6	2388.7	42.022	2477.2	2519.2	0.1511	8.7488	8.8999
15	1.7057	0.001001	77.885	62.980	2332.5	2395.5	62.982	2465.4	2528.3	0.2245	8.5559	8.7803
20	2.3392	0.001002	57.762	83.913	2318.4	2402.3	83.915	2453.5	2537.4	0.2965	8.3696	8.6661
25	3.1698	0.001003	43.340	104.83	2304.3	2409.1	104.83	2441.7	2546.5	0.3672	8.1895	8.5567
30	4.2469	0.001004	32.879	125.73	2290.2	2415.9	125.74	2429.8	2555.6	0.4368	8.0152	8.4520
35	5.6291	0.001006	25.205	146.63	2276.0	2422.7	146.64	2417.9	2564.6	0.5051	7.8466	8.3517
40	7.3851	0.001008	19.515	167.53	2261.9	2429.4	167.53	2406.0	2573.5	0.5724	7.6832	8.2556
45	9.5953	0.001010	15.251	188.43	2247.7	2436.1	188.44	2394.0	2582.4	0.6386	7.5247	8.1633
50	12.352	0.001012	12.026	209.33	2233.4	2442.7	209.34	2382.0	2591.3	0.7038	7.3710	8.0748
55	15.763	0.001015	9.5639	230.24	2219.1	2449.3	230.26	2369.8	2600.1	0.7680	7.2218	7.9898
60	19.947	0.001017	7.6670	251.16	2204.7	2455.9	251.18	2357.7	2608.8	0.8313	7.0769	7.9082
65	25.043	0.001020	6.1935	272.09	2190.3	2462.4	272.12	2345.4	2617.5	0.8937	6.9360	7.8296
70	31.202	0.001023	5.0396	293.04	2175.8	2468.9	293.07	2333.0	2626.1	0.9551	6.7989	7.7540
75	38.597	0.001026	4.1291	313.99	2161.3	2475.3	314.03	2320.6	2634.6	1.0158	6.6655	7.6812
80	47.416	0.001029	3.4053	334.97	2146.6	2481.6	335.02	2308.0	2643.0	1.0756	6.5355	7.6111
85	57.868	0.001032	2.8261	355.96	2131.9	2487.8	356.02	2295.3	2651.4	1.1346	6.4089	7.5435
90	70.183	0.001036	2.3593	376.97	2117.0	2494.0	377.04	2282.5	2659.6	1.1929	6.2853	7.4782
95	84.609	0.001040	1.9808	398.00	2102.0	2500.1	398.09	2269.6	2667.6	1.2504	6.1647	7.4151
100	101.42	0.001043	1.6720	419.06	2087.0	2506.0	419.17	2256.4	2675.6	1.3072	6.0470	7.3542
105	120.90	0.001047	1.4186	440.15	2071.8	2511.9	440.28	2243.1	2683.4	1.3634	5.9319	7.2952
110	143.38	0.001052	1.2094	461.27	2056.4	2517.7	461.42	2229.7	2691.1	1.4188	5.8193	7.2382
115	169.18	0.001056	1.0360	482.42	2040.9	2523.3	482.59	2216.0	2698.6	1.4737	5.7092	7.1829
120	198.67	0.001060	0.89133	503.60	2025.3	2528.9	503.81	2202.1	2706.0	1.5279	5.6013	7.1292
125	232.23	0.001065	0.77012	524.83	2009.5	2534.3	525.07	2188.1	2713.1	1.5816	5.4956	7.0771
130	270.28	0.001070	0.66808	546.10	1993.4	2539.5	546.38	2173.7	2720.1	1.6346	5.3919	7.0265
135	313.22	0.001075	0.58179	567.41	1977.3	2544.7	567.75	2159.1	2726.9	1.6872	5.2901	6.9773
140	361.53	0.001080	0.50850	588.77	1960.9	2549.6	589.16	2144.3	2733.5	1.7392	5.1901	6.9294
145	415.68	0.001085	0.44600	610.19	1944.2	2554.4	610.64	2129.2	2739.8	1.7908	5.0919	6.8827
150	476.16	0.001091	0.39248	631.66	1927.4	2559.1	632.18	2113.8	2745.9	1.8418	4.9953	6.8371
155	543.49	0.001096	0.34648	653.19	1910.3	2563.5	653.79	2098.0	2751.8	1.8924	4.9002	6.7927
160	618.23	0.001102	0.30680	674.79	1893.0	2567.8	675.47	2082.0	2757.5	1.9426	4.8066	6.7492
165	700.93	0.001108	0.27244	696.46	1875.4	2571.9	697.24	2065.6	2762.8	1.9923	4.7143	6.7067
170	792.18	0.001114	0.24260	718.20	1857.5	2575.7	719.08	2048.8	2767.9	2.0417	4.6233	6.6650
175	892.60	0.001121	0.21659	740.02	1839.4	2579.4	741.02	2031.7	2772.7	2.0906	4.5335	6.6242
180	1002.8	0.001127	0.19384	761.92	1820.9	2582.8	763.05	2014.2	2777.2	2.1392	4.4448	6.5841
185	1123.5	0.001134	0.17390	783.91	1802.1	2586.0	785.19	1996.2	2781.4	2.1875	4.3572	6.5447
190	1255.2	0.001141	0.15636	806.00	1783.0	2589.0	807.43	1977.9	2785.3	2.2355	4.2705	6.5059
195	1398.8	0.001149	0.14089	828.18	1763.6	2591.7	829.78	1959.0	2788.8	2.2831	4.1847	6.4678
200	1554.9	0.001157	0.12721	850.46	1743.7	2594.2	852.26	1939.8	2792.0	2.3305	4.0997	6.4302

Sumber: Buku *Thermodinamics, an Engineering Approach*, Hal.904(Cengel dan Boles, 2015).