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The Design of DC 12 V to DC 380 V 1000 Watt Converter with ATmega328 as a 65 KHz Oscillator

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Abstract. A DC to DC converter has been built and research has been conducted to examine the effect of load on the output voltage of the DC to DC converter with fixed oscillation frequency. This converter DC to DC circuit uses a 12 V DC battery as an input voltage source connected with a step-up transformer until it is successfully raised to 380 V DC. The load given to the DC to DC circuit converter in the form of lamps, varies from 40 watts to 960 watts with a fixed oscillation frequency of 65 Khz that has been determined by the microcontroller. The test results showed that the output voltage value decreased in accordance with the increase in load so that when the load of 960 watts obtained the output voltage of 220 V DC.

Keyword: Transformer, Microcontroller, DC-DC Converter.

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1 Introduction

Power with a voltage value of 380V DC is efficient power when compared to electrical power voltage of 220V AC. The 220V AC electrical network began to be abandoned for the purposes of the data network management power grid. The DC 380 V power grid can be easily merged from a variety of different energy sources, from wind, water, solar and fuel oil power plants. In the application of renewable energy sources, wind energy and solar energy produce low and unstable output voltage. The resulting voltage is stored on the battery and a device is needed to raise the voltage [1]. In addition, some renewable energy sources are available very abundantly and free from pollution [2]. Conversion of solar and wind energy into electricity and merging several types of renewable and non-renewable energy using controllers to optimize the utilization of energy sources and use batteries as their energy storage [3]. Current technological developments encourage researchers to develop the utilization of renewable energy sources, in this case solar cells. In its use the electrical energy produced by the solar cell is then stored in accu before being channeled to the load. The problem that then arises is, the power storage in

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accu is at voltages of 12 and 24 Volt DC while some existing loads require a voltage of 220 volts and above [4].

Electricity can be obtained from power plants or energy storage such as batteries. Thomas A. Edison actually started the revolution when he proposed the use of electricity instead of natural gas to light up the house. In the industry we may think of it as a dramatic change in idea or practice. Evolution on the other hand can be considered a gradual development of something into a better form. With the main purpose of data centers as reliability and secondary purposes being to manage costs, one should look at macro trends in terms of power, computing, and reliability [5]. Electrical power is the amount of energy absorbed or produced in a circuit. Energy sources such as electric voltage will produce electrical power while the load connected to it will absorb the electrical power. In other words, electrical power is the level of energy consumption in a circuit or electrical circuit. While based on the concept of business, what is meant by electrical power is the amount of effort in moving the charge per unit of time or shorter is the amount of electrical energy used per second [6]. Electrical power is defined as the rate of electrical energy delivery in the electrical circuit. Si unit of electrical power is a wattage that says the number of electricity flowing unity of time (joule / sekon). Electric currents flowing in circuits with electrical resistances give rise to work. The device converts this work into various useful forms, such as heat (electric heater), light (light bulb), kinetic energy (electric motor), and sound (loudspeaker) [7].

The application of DC–DC converter in its development has enabled an electronic device to function by using a small voltage battery energy source where output voltage can be changed according to usage needs. Electronic converter technology has been widely used in everyday life, for example its application, DC-DC converter is used in renewable energy sources as an energy producer such as in wind and solar power [8]. A DC-DC converter is an electronic circuit and is used to modify the DC electrical circuit from one potential different stage to add a potential level of difference. A DC-DC circuit converter that converts a DC source from one voltage level to another by changing the task cycle of the main switch in the circuit. Dc-DC converters are widely used in power mode switch supply, adjustable speed drives, disconnected power supply (UPS) and many other [9].

Step-up DC-DC konverter yang banyak digunakan untuk meningkatkan tingkat tegangan input rendah dari sistem listrik didistribusikan. Sistem ini didukung oleh sumber energi terbarukan seperti panel surya, baterai, dan sel bahan bakar. Sebuah tren baru dalam sistem generasi fotovoltaik perumahan untuk mengadopsi konfigurasi paralel daripada koneksi seri untuk memenuhi persyaratan keselamatan saat menggambar daya maksimum yang tersedia dari PV panel [10].

The AC/DC converter in normal operation has a wide input voltage range to close and provide a high efficiency regulated output voltage. DC/DC converters used in 380 V DC systems usually have a stable input voltage, as the batteries in dc boots the input voltage to the DC/DC converter only changes during the charging cycle and battery emptying. The input voltage can range from 12-50 V and the output voltage is usually 380 V. A conventional boost converter will have a difficult time increasing the input voltage and maintaining high efficiency simultaneously [11]. Data center power topology 380V DC is one of the macro trends. The 380V DC provides the most flexible and cost-effective system to meet fluctuating energy demand that will take advantage of all the engineering benefits of direct current [12].

Small voltage changes in the gate result in voltage changes in resistance resulting in reinforcement. The increase in gate voltage resulted in a decrease in drain voltage, so there was a 180° phase shift between input and FET output [13]. Low working voltage, passive switches (diodes) are often replaced with active switches (MOSFET) so that the power supply on the switch can be reduced. When using 2 active switches, both switches will work alternately, and there is only one switch that closes at any time. The average output voltage value of the converter is proportional to the ratio between the closing time of the switch (conduction switch/ON) to its claiming period. The value of this power factor is not less than 0.2, because if operated at a higher voltage ratio, the switch will work under its reliability and cause the converter's efficiency to drop [14]. If the MOSFET IS OFF then the current flows to the inductor, the energy stored in the inductor will rise. When the MOSFET SWITCH ON the energy in the inductor will drop and the current flows towards the load. In this way, the average value of the output voltage will correspond to the ratio between the opening time and the closing time of the switch. This is what makes this topology can produce an average value of output voltage / load higher or lower than the source voltage [15].

Direct voltage or dc is widely used in the industry, not only as an electric power source dc motor, but also a lot for other applications. Usually dc voltage is obtained from ac voltage that is targeted with semiconductor components such as diodes, thyristor, mosfet etc. This dc voltage must not only be filtered cleanly but also well regulated. If the current source in this direction is charged then the output voltage will change. This change is caused by the fall of voltage in diodes, channels, transformers or in generators if the source is directly from the generator [16]. Buck-boost converters can produce output voltages lower or higher than the source. The power control circuit will signal the MOSFET.

A commonly used tool today is the DC-DC boost converter. This DC-DC converter is widely used for applications that require a higher voltage than its source [17]. DC-DC boost converter is a converter used to provide output voltage higher than low input voltage by controlled by control signal in the form of PWM signal (Pulse Width Modulation) [18].

2 Methods

This research was conducted in digital technology laboratory of University of North Sumatra which includes the design of tools and data calculation.

The converter is designed with three main components, namely: Arduino as a data processor of sensors, a series of push pull ups to increase output voltage and FET Logic Driver to set the current and voltage values of the circuit.

The structural design is given in Figure 1 and the flowchart in Figure 2.

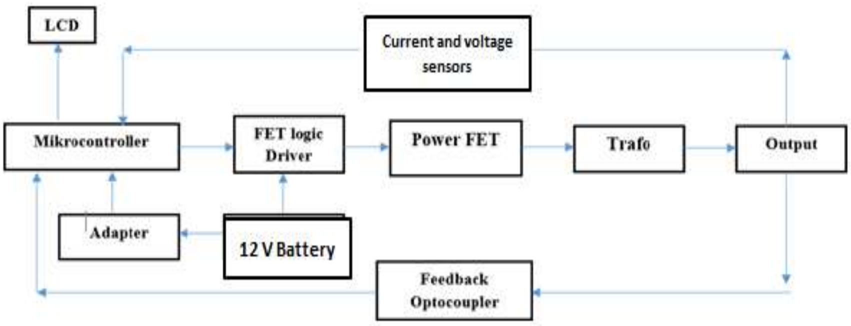

Figure 1. The block diagram of the research

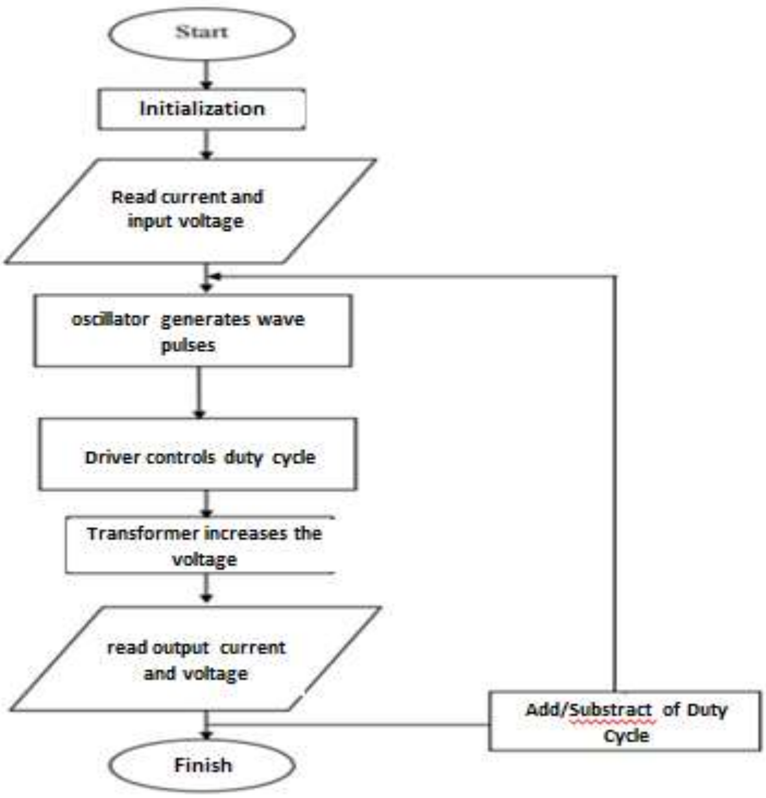

Figure 1. Flowchart of the research

3 Result and Discussion

3.1 Load Testing Vs voltage

This test aims to find out the effect of load on output from DC-DC converter. Testing is done by changing the load and measuring the voltage generated by the DC DC converter.

Table 1. Effect of Load on Voltage

Number	Load (Watt)	V_{in} (V)	I_{Input} (A)	V_{Out} (V)	I_{Output} (A)
1	40	13.65	2.92	215.2	0.15
2	40	13.64	2.86	215.9	0.14
3	40	13.65	2.94	215.7	0.15
4	40	13.63	2.83	215.9	0.14
5	40	13.65	2.94	215.2	0.15
6	75	13.45	5.55	211.82	0.28
7	75	13.48	5.52	211.38	0.27
8	75	13.44	5.5	211.38	0.27
9	75	13.48	5.51	211.5	0.28
10	75	13.4	5.49	211.51	0.28
11	100	13.25	7.42	205.2	0.38
12	100	13.26	7.46	205.1	0.37
13	100	13.18	7.4	205.3	0.37
14	100	13.2	7.5	205.5	0.38
15	100	13.22	7.3	205.3	0.36
16	150	12.88	11.2	192.3	0.6
17	150	12.9	11.22	192.5	0.58
18	150	12.86	11.26	192.3	0.59
19	150	12.84	11.2	192.7	0.57
20	150	12.84	11.4	192.3	0.58
21	200	12.6	15.72	186.4	0.8
22	200	12.64	15.7	186.1	0.82
23	200	12.64	15.72	186.3	0.83
24	200	12.68	15.72	186.38	0.8
25	200	12.63	15.7	186.6	0.8
26	240	12.56	19.9	175.2	1.07
27	240	12.56	19.87	175.9	1.08
28	240	12.55	19.8	175.7	1.06
29	240	12.56	19.87	175.68	1.08
30	240	12.53	19.94	175.2	1.07

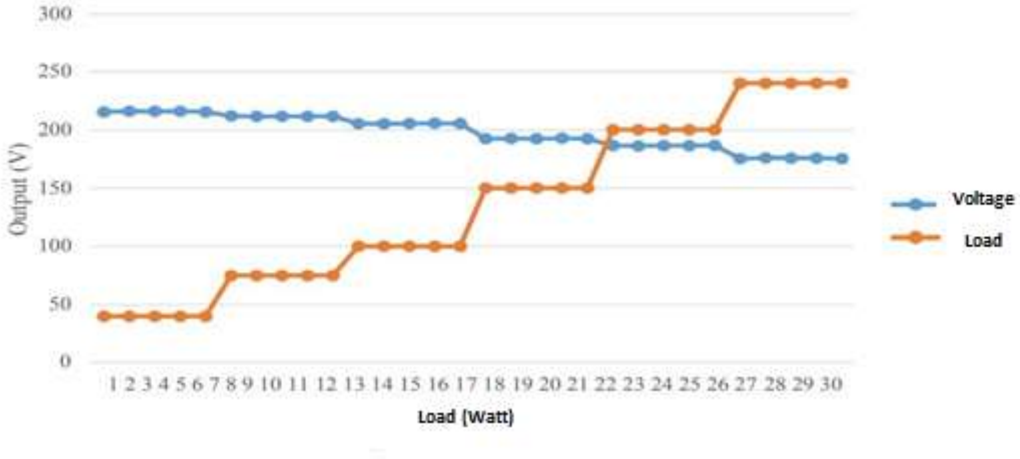

Figure 3. Load graph to voltage

Figure 3 shows the greater the load given to the circuit, the lower the output voltage obtained on the system. The output voltage value is inversely proportional to the given load.

3.2 Testing of Efficiency of DC-DC converter

The efficiency of the DC to DC Converter can be found by calculating the ratio of the input power (Pin) and Output power (POut) on the DC to DC Converter in each experiment using the equation (1), and the results are given in Table 2 to Table 7.

$$\text{Efficiency} = \frac{P_{out}}{P_{in}} x100\% \quad (1)$$

Table 2. Efficiency Testing Data with a load of 40 Watts

Experiment	V_{in} (V)	I_{in} (A)	V_{out} (V)	I_{out} (A)	P_{In} (W)	P_{Out} (W)	Eficiency (%)
1	13.65	2.92	215.2	0.15	39.858	32.28	80.98751
2	13.64	2.86	215.9	0.14	39.0104	30.226	77.4819
3	13.65	2.94	215.7	0.15	40.131	32.355	80.62346
4	13.63	2.83	215.9	0.14	38.5729	30.226	78.36071
5	13.65	2.94	215.2	0.15	40.131	32.28	80.43657
6	13.65	2.96	215.2	0.15	40.404	32.28	79.89308
7	13.63	2.93	215.9	0.14	39.9359	30.226	75.68629
8	13.65	2.83	215.8	0.15	38.6295	32.37	83.79606
9	13.65	2.92	215.7	0.14	39.858	30.198	75.76396
10	13.63	2.91	215.1	0.14	39.6633	30.114	75.92409
11	13.65	2.94	215.5	0.15	40.131	32.325	80.5487
12	13.65	2.94	215.5	0.15	40.131	32.325	80.5487
13	13.66	2.91	215.7	0.14	39.7506	30.198	75.96866
14	13.65	2.94	215.6	0.15	40.131	32.34	80.58608
15	13.65	2.93	215.8	0.14	39.9945	30.212	75.54039
16	13.67	2.87	215.9	0.15	39.2329	32.385	82.54552
Average efficiency							79.04323

Table 3. Efficiency Testing Data with a load of 75 Watt

Experiment	V_{in} (V)	Iin (A)	Vout(V)	Iout(A)	P In (W)	P Out (W)	Eficiency (%)
1	13.45	5.55	211.82	0.28	74.6475	59.3096	79.4529
2	13.48	5.52	211.38	0.27	74.4096	57.0726	76.70059
3	13.44	5.5	211.38	0.27	73.92	57.0726	77.2086
4	13.48	5.51	211.5	0.28	74.2748	59.22	79.73095
5	13.4	5.49	211.51	0.28	73.566	59.2228	80.50295
6	13.42	5.47	211.5	0.27	73.4074	57.105	77.79188
7	13.46	5.48	211.48	0.28	73.7608	59.2144	80.27896
8	13.44	5.54	211.6	0.28	74.4576	59.248	79.5728
9	13.49	5.48	211.7	0.26	73.9252	55.042	74.45634
10	13.42	5.46	211.5	0.29	73.2732	61.335	83.70728
11	13.44	5.48	211.5	0.28	73.6512	59.22	80.40602
12	13.4	5.38	211.2	0.29	72.092	61.248	84.95811
13	13.48	5.5	211.7	0.26	74.14	55.042	74.24063
14	13.41	5.4	211.2	0.27	72.414	57.024	78.7472
15	13.4	5.56	211.5	0.28	74.504	59.22	79.48567
16	13.46	5.54	211.65	0.28	74.5684	59.262	79.47334
Average efficiency							79.16964

Table 4. Efficiency Testing Data with a load of 100 Watt

Experiment	Vin (V)	Iin (A)	Vout(V)	Iout(A)	P In (W)	P Out (W)	Eficiency (%)
1	13.25	7.42	205.2	0.38	98.315	77.976	79.31241
2	13.26	7.46	205.1	0.37	98.9196	75.887	76.71584
3	13.18	7.4	205.3	0.37	97.532	75.961	77.88316
4	13.2	7.5	205.5	0.38	99	78.09	78.87879
5	13.22	7.3	205.3	0.36	96.506	73.908	76.58384
6	13.24	7.4	205.4	0.35	97.976	71.89	73.37511
7	13.2	7.2	205.2	0.34	95.04	69.768	73.40909
8	13.18	7.4	205.3	0.33	97.532	67.749	69.46336
9	13.26	7.4	205.5	0.38	98.124	78.09	79.58298
10	13.16	7.44	205.6	0.39	97.9104	80.184	81.89528
11	13.18	7.46	205.6	0.38	98.3228	78.128	79.46072
12	13.22	7.39	205.7	0.38	97.6958	78.166	80.00958
13	13.26	7.45	205.3	0.37	98.787	75.961	76.89372
14	13.28	7.43	205.6	0.38	98.6704	78.128	79.18079
15	13.2	7.2	205.2	0.4	95.04	82.08	86.36364
16	13.21	7.42	205.1	0.39	98.0182	79.989	81.60627
Average efficiency							78.16341

Table 5. Efficiency Testing Data with a load of 150 watt

Experiment	Vin (V)	Iin (A)	Vout(V)	Iout(A)	P In (W)	P Out (W)	Eficiency (%)
1	12.88	11.2	192.3	0.6	144.256	115.38	79.98281
2	12.9	11.22	192.5	0.58	144.738	111.65	77.13938
3	12.86	11.26	192.3	0.59	144.8036	113.457	78.35233
4	12.84	11.2	192.7	0.57	143.808	109.839	76.37892
5	12.84	11.4	192.3	0.58	146.376	111.534	76.19692
6	12.88	11.25	192.4	0.59	144.9	113.516	78.34092
7	12.9	11.26	192.6	0.6	145.254	115.56	79.55719
8	12.84	11.2	192.3	0.6	143.808	115.38	80.23198
9	12.83	11.2	192.6	0.58	143.696	111.708	77.73912
10	12.88	11.28	192.8	0.6	145.2864	115.68	79.62204
11	12.9	11.2	192.6	0.58	144.48	111.708	77.31728
12	12.92	11.25	192.7	0.6	145.35	115.62	79.54592
13	12.9	11.18	192.4	0.58	144.222	111.592	77.37516
14	12.8	11.16	192.6	0.56	142.848	107.856	75.50403
15	12.84	11.22	192.3	0.54	144.0648	103.842	72.08006
16	12.81	11.16	192.5	0.58	142.9596	111.65	78.09899
Average efficiency							77.71644

Table 6. Efficiency Testing Data with a load of 200 Watt

Experiment	Vin (V)	Iin (A)	Vout (V)	Iout (A)	P In (W)	P Out (W)	Eficiency (%)
1	12.6	15.72	186.4	0.8	198.072	149.12	75.28575
2	12.64	15.7	186.1	0.82	198.448	152.602	76.89773
3	12.64	15.72	186.3	0.83	198.7008	154.629	77.82002
4	12.68	15.72	186.38	0.8	199.3296	149.104	74.80274
5	12.63	15.7	186.6	0.8	198.291	149.28	75.2833
6	12.65	15.78	186.48	0.84	199.617	156.6432	78.47187
7	12.66	15.75	186.2	0.82	199.395	152.684	76.57364
8	12.64	15.7	186.5	0.84	198.448	156.66	78.94259
9	12.6	15.74	186.52	0.85	198.324	158.542	79.9409
10	12.68	15.77	186.48	0.81	199.9636	151.0488	75.53815
11	12.7	15.74	186.7	0.82	199.898	153.094	76.58606
12	12.68	15.75	186.3	0.82	199.71	152.766	76.49392
13	12.71	15.78	186.5	0.81	200.5638	151.065	75.32017
14	12.68	15.76	186.6	0.84	199.8368	156.744	78.436
15	12.65	15.68	186.5	0.82	198.352	152.93	77.10031
16	12.68	15.76	186.4	0.81	199.8368	150.984	75.55365
Average efficiency							76.81543

Table 7. Efficiency Testing Data with a load of 240 Watt

Experiment	Vin (V)	Iin (A)	Vout (V)	Iout (A)	P In (W)	P Out (W)	Eficiency (%)
1	12.56	19.9	175.2	1.07	249.944	187.464	75.0024
2	12.56	19.87	175.9	1.08	249.5672	189.972	76.12058
3	12.55	19.8	175.7	1.06	248.49	186.242	74.94949
4	12.56	19.87	175.68	1.08	249.5672	189.7344	76.02538
5	12.53	19.94	175.2	1.07	249.8482	187.464	75.03116
6	12.54	19.7	175.2	1.1	247.038	192.72	78.01229
7	12.58	19.86	175.9	1.09	249.8388	191.731	76.74188
8	12.57	19.84	175.6	1.08	249.3888	189.648	76.04512
9	12.54	19.8	175.7	1.08	248.292	189.756	76.42453
10	12.55	19.9	175.1	1.08	249.745	189.108	75.72043
11	12.54	19.68	175.5	1.05	246.7872	184.275	74.66959
12	12.53	19.7	175.48	1.09	246.841	191.2732	77.48842
13	12.56	19.88	175	1.05	249.6928	183.75	73.59043
14	12.57	19.87	175.7	1.08	249.7659	189.756	75.97354
15	12.54	19.89	175.6	1.05	249.4206	184.38	73.92332
16	12.56	19.7	175.8	1.09	247.432	191.622	77.44431
Average efficiency							75.82268

Table 8. Efficiency Value of DC to DC Converter

Number	Load (Watt)	Eficiency (%)
1	40	79.04323
2	75	79.16964
3	100	78.16341
4	150	77.71644
5	200	76.81543
6	240	75.82268
Average Eficiency		77.7884

Based on Table 8, the greater the load used, the efficiency of DC to DC Converter decreases, this is due to the step-up transformer working above its working rating, the higher the primary current then most of its power is converted into heat. From the data above, the average efficiency of DC to DC Converter is 77.78%. This efficiency value is influenced by step-up transformers and on the reasoning where each switch component is given a large load so that some of it becomes a loss in the form of heat.

4 Conclusion

From the results of the design of the tool to the testing and discussion of the system, the author can draw conclusions:

1. DC to DC Converter converts 12V DC to 380 V DC, the voltage obtained is about 220 V to 380 V using a frequency value of 65 Khz.
2. Power produced by 240 Watts by using a lamp module as a load, using four lamp modules, the power generated is 960 Watts (~1000 Watts).
3. The results of this research can be used directly on inverter DC to DC pure sine.

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