Utilization of Solar Power in Distributing Substation

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***Abstract*—A Solar Energy System is sometimes referred to as an alternative energy system. And while that's true, wind, geothermal, and hydro systems are also alternative energy sources. This paper presents the solution of the heating of the substations in Libya by using the solar panel to produce the electricity that feed the substation itself by a fan to cool the substation. We focus on solar energy as an alternative energy to cool the substations in a located country (Libya) as mentioned. The propose of this paper is using a dc- to-dc converter, which offers continuous input and output energy flow and low input current ripple, applicable and mandatory for photovoltaic (PV) arrays and maximum power tracking applications. Conventional dc-to-dc converters have a relatively high input current ripple, which causes high power losses when connected to nonlinear sources like PV arrays. Converter simulations and experimental results support and extol the system concept.**

***Index Terms*—cooling using photovoltaic systems, DC/DC converters**

I. Introduction

We have all been told that solar energy is the future and that solar energy will be one-day power our entire civilization with clean, renewable, low cost energy. The idea of this paper is to find the optimal solution of the heat on the electrical sub- stations. Simply as sunlight contribute to the heat increase in the substations equipment; we turn this problem in to cooling down the substations by using a simple control circuit and a PV solar panel feeding an inverter that controls fans speed. In summary, we change the sunlight from being a source of heat to cooling down the place under interest.

II. Why Do Not We Use the Caused of the Problem for the Solution?

The mean reason for increasing the electrical equipment and burning, it is the heat of sun rising especially in Libya. So why we don't use fans which working by solar energy for cooling the sub-stations without the need to take extra voltage to turn on the fans from the distribution sub- station transforms especially that when the taken voltage is increasing from the equipment the temperature is also increasing but it is working by PV solar energy and its connected to the known control circuit which the fans doesn't work in normal temperature degrees.

We save the energy derived from the solar energy to the batteries by function supply voltage to the electrical protection and another sub-station equipment and also for internal lighting.

The most important thing is that to turn on the cooling fans when the temperature is increasing inside the station based on the measured from sensors are calibrated at a given temperature to cool the station.

Especially the peak load hours in Libya at two in the afternoon when the Employees came to their homes and for this condition, we can turn on the fans from the solar energy immediately without the need for batteries exhausted of electrical power.

And the second peak load hours are the sunset time that belongs to the General Electricity Company of Libya (Gecol). And in this case the fans are working from the batteries until the equipment temperature is decreasing and after they saved energy is using for protection equipment and the sub-station lighting and dispensing the charger is located at the station which the most affected station equipment and replaced by the solar energy panel.

III. How Is Light Turned to Electricity?

It is just another form of energy conversion. Really, it is no different to burning wood; energy from the sun is turned into chemical energy in the wood.

Burning the wood converts chemical energy to heat energy.

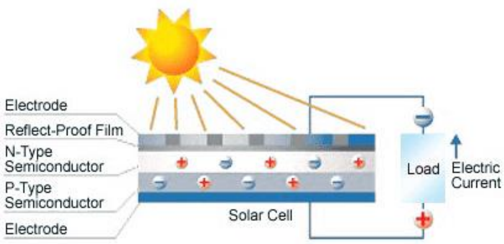

Figure 1. How is light turned into electricity?

When the sun shines on a solar panel, the photovoltaic effect converts the light energy to electrical energy as shown in Fig. 1. The power from the solar panel is proportional to the amount of light shining on it that is if the light gets twice as bright Ref. [1]. Components of a Solar Power System:

1. Solar Panels.

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2. Charge Controller.
3. Power Inverter.
4. Surge Arrestors.
5. Storage Batteries.
6. Transfer swatch.

IV. Advantages

The advantages of the continuity of the electricity to avoid the cutting operations for the distribution of the substations and cooling the substation as the following points

- Provide continue energy source when the substation by black out (of the electrical grid) more than one day for main tenancy.
- Provide the internal transformer costs that useless after the electrical cut more than storage batteries time.
- Savings in main tenancies costs compared to traditional maintenance expenses stations.
- Provide possibility of cooling the substations in rush hours and the high temperature without the need for intervention by the maintenance teams.
- The possibility of operating the station equipment after a power on the station in the daytime so that batteries are not taken the power it as it happens in traditional nutrition and utilization of solar energy for supplying the equipment immediately in daytime and charge the batteries.
- Benefit from the development of solar cells on rooftops electricity distribution stations so the station to avoid direct sunlight, which that utilizing of radiation at the plant cooling process.

V. Types of Solar Panels

There are number of different types of solar panels, from an ever-increasing range of manufacturers. Each requires that they are best for one reason or others; better suited to the UK's duller conditions, but the difference is marginal. The appearance is also different you can see the random crystal arrangement and the panels look a little bluer as they reflect some of the light.

With different sales people all giving different information. We are not tied to any particular manufacturer and do not hold stocks of solar panels, so that we are flexible enough to be able to recommend whichever solar panel we think is the best for your project and can just order and fit the type of panel that you prefer.

There are three main types of solar panels:

- Mono crystalline solar panels.
- Poly crystalline solar panels.
- Amorphous solar panel.

A. Mono-Crystalline Solar Panels

The solar cells in mono-crystalline panels as in Fig. 2 are slices cut from pure drawn crystalline silicon bars. The entire cell is aligned in one direction, which means that when the sun is shining brightly on them at the correct angle, they are extremely efficient, so these panels work best in bright sunshine with the sun shining directly on them. They have a uniform blacker colour because they are absorbing most of the light. Pure cells are octagonal, so there is unused space in the corners when lots of cells are made into a solar module. Mono panels are slightly smaller than poly panels for the same power, but this is only really noticeable on industrial scale installations where you may be able to fit a higher overall power with mono-crystalline.

Mono-crystalline silicon offers high efficiency and good heat tolerance characteristics in a small footprint. An example of a quality mono- crystalline solar panel is the Daqo 250-watt mono module Ref. [2].

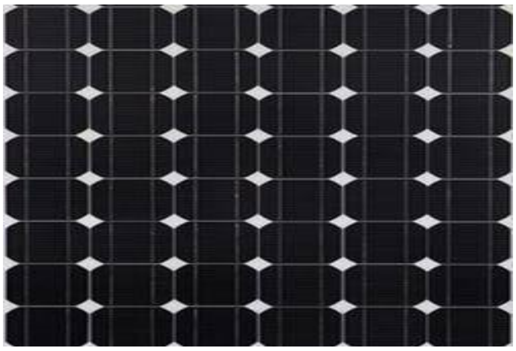

Figure 2. Mono-crystalline solar panels

B. Poly-Crystalliinesolar Panels

Polycrystalline panels are made up from the silicon off-cuts, molded to form blocks and create a cell made up of several bits of pure crystal. Because the individual crystals are not necessarily all perfectly aligned together and there are losses at the joints between them, they are not quite as efficient. However, this miss-alignment can help in some circumstances, because the cells work better from light at all angles, in low light, etc.

For this reason, we would argue that polycrystalline is slightly.

Since they are cut into rectangular blocks, there is very little wasted space on the panel and you do not see the little diamonds that are typical of mono or hybrid panels.

Some people prefer this more uniform appearance, others like the diamonds. The choice is yours because the overall size and cost is very similar to mono-crystalline Ref. [2].

Polycrystalline (or multi-crystalline) silicon cell based solar panels are now the most popular choice in residential installs. Recent improvements in polycrystalline panel technology have resulted in the development of modules equal to or better than many mono-crystalline brands in terms of size, efficiency and heat tolerance. One of the world's leading producers of polycrystalline panel Ref. [3].

C. Amorphous Solar Panel

Amorphous (or thin-film) silicon uses the least amount of silicon. While some thin film panels are among the least efficient solar cells, Solar Frontier CIS solar panels offer the highest conversion efficiency of any mass-produced thin-film module Ref. [3].

Figure 3. Mono crystalline solar panels

We will use this panel in Fig. 3 for our design which called Mono crystalline solar panel. This panel cost 250$ create 250 w.

VI. DC-DC Converter

The table of Manufactured Boost Converters that using to design the DC-DC converter for boost converter.

TABLE I. Manufactured Boost Converters

Model (Boost)	Vin			Vout			Switch Frequency			Current
	Min	Typ	Max	Min	Typ	Max	Min	Typ	Max	Max
TPS61086	2.0	5.0	5.5	5.0	12.0	18.0	1 MHz		1.4 MHz	2 A
BP5311A	4.5	5.0	5.5	28.0	29.5	31.0				25 mA
ADD8754	3.0		5.5			20.0	650 kHz		1.2 MHz	2.6 A
MAX8758ETG	1.8		5.5	4.5		13.0	990 kHz		1.38 MHz	10 mA
TPS61093	1.6		6.0	1.6		17.0	1.0 MHz		1.4 MHz	.3 A
TPS61241	2.3		5.5	5.0		5.0	3.8 MHz		4.2 MHz	.6 A
TPS61175	2.9		18.0	2.9		38.0	2.0 MHz		2.4 MHz	3 A
UC2577-ADJ	3.0		40.0	5.0		60.0	50 kHz		54 kHz	3 A
ADP5025	2.5		5.5			5.0	2.3 MHz		2.7 MHz	1.2 A

A. *What is a DC/DC Boost Converter?*

Boost converters are essentially a step-up power converter that take in a low voltage input and provide an output at a much higher voltage. Table I is explained the manufactured of boost converter. A block diagram of the ideal of dc/dc boost converter is shown in the Fig. 4.

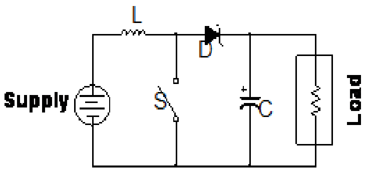

Figure 4. Open loop boost converter.

The input and output voltage relationship is controlled by the switch duty cycle, D, according to the equation (1).

$$Vout = \left(\frac{1}{1-D}\right)Vin \qquad (1)$$

Equation (1): Input/output Characteristic of a Boost Converter.

B. *Different Methods for Achieving a DC/DC Boost Converter*

To build this boost converter that meets the teams' specifications the team needs the power stage that will provide the 12V output from a 3.3V input. This circuit will be the daughterboard of the design. To set the desired frequency for this converter the teams needs to design a pulse width modulation (PWM) circuit up to 20MHz to drive the boost converter. Fig. 5 shows a block diagram for the boost converter Ref. [4].

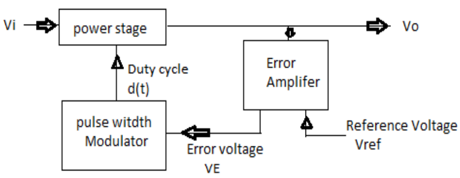

Figure 5. Building blocks of a boost converter system.

We have used the three kinds of converters as shown below:

- Çuk converter .
- C converter.
- D converter.

According to the reference number [6] that taken from a paper which published in April 4, 2015.

The conclusion that we have found is the D converter is the best one of the 3 converters as mentioned in Fig. 6 in sequence (a) Çuk, (b) C, and (c) D. because it is solved the ripple for the input and output for the current in the circuit converter.

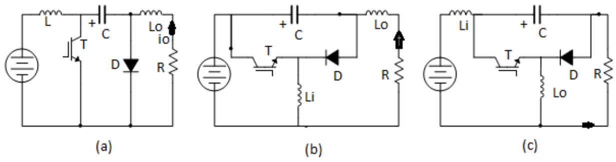

Figure 6. Converters with buck–boost transfer function, continuous input/output current, and same number of components: (a) Cuk, (b) C, and (c) D.

As we will see in the Fig. 7 that explained the general structure of dc-to-dc converters and D- converter circuit which we are going to use in our design.

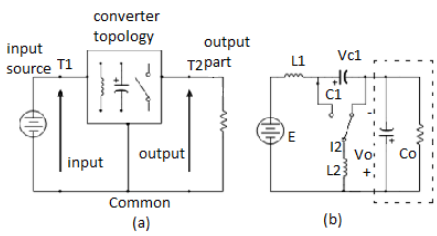

Figure 7. (a) General structure of dc-to-dc converters. (b) *D* converter circuit showing the synchronization of switch and diode.

VII. Pulse Width Modulation (PWM)

The fundamental principle involved in making a boost converter is creating a square pulse to control the switching of the MOSFET. This square pulse is called the duty cycle; this duty cycle (D) controls the output voltage. The transfer function is derived by the previous set of equations. Fig. 8 is the ideal gate voltage to be able to switch the MOSFET and create a boosted output voltage. The y-axis shows VGS (V) and the x-axis shows the time interval of the signal Ref. [4].

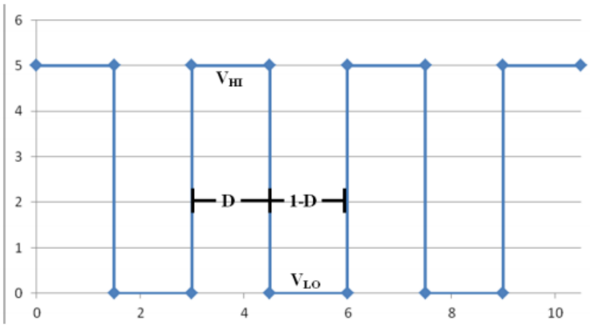

Figure 8. Gate voltage on MOSFET

VIII. The Criteria for Selecting the DC-to-DC Converters

The criteria for selecting the dc-to-dc converters Ref. [5] in the PV system depend on many factors such:

- Cost.
- Efficiency.
- Flexibility.
- Energy flow.

IX. Stup up Switch Ideal Boost Converter

The boost converter, also known as the step-up converter, is another switching converter that has the same components as the buck converter, but this converter produces an output voltage greater than the source. The ideal boost converter has the five basic components, namely a power semiconductor switch, a diode, an inductor, an electrolytic capacitor and a Pulse Width Modulation (PWM) controller. The placement of the inductor, the switch and the diode in the boost converter is different from the buck converter. The basic circuit of the boost converter is shown in Fig. 9.

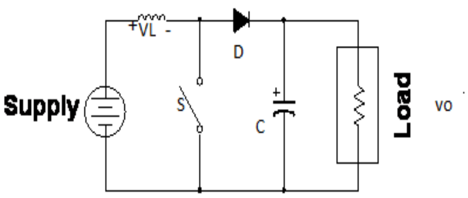

Figure 9. Step up converter basic circuit

X. Application of Using Solar Power System

There are three most important and widely used applications of Solar PV have been considered here. They are:

- Solar home lighting systems.
- Solar water pumping systems.
- Solar power plants. Ref. [5].

XI. Application of Solar Energy in Everyday Lives

There is a great variety of ways in which solar energy can be utilized. It can be used for electricity generation, for heating purposes, cooling, cooking and many other applications that are useful in our daily lives. Each of these applications, when based on solar energy, varies greatly in costs and other features.

Following are some ways how you can use solar energy in your daily lives:

- Generate electricity with solar panels.
- Passive space heating
- Heat up air and water
- Warm up food
- Heat your swimming pool water
- Enhance your landscaping
- Water your plants with solar powered irrigation.

XII. Peak Sun Hours

The number of peak sun conditions (i.e., at $1kW/m^2$) that produces the same total insulation as actual sun conditions shown in Fig. 11 Ref. [6].

This section presents the map of sun rising of Libyan geographic and the map shows the among of sun rising for each part of Libya and the Fig. 10 below shows how much we need to change the problem to the solution by using solar energy for decreasing the high temperature for the electrical distribution which comes from the sun.

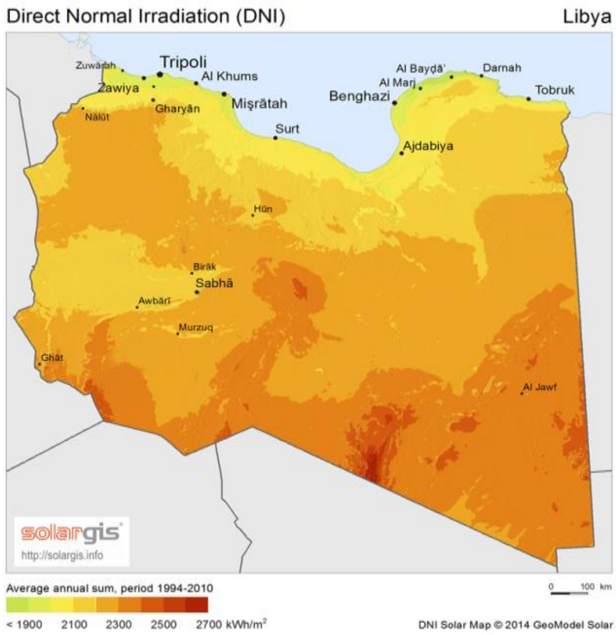

Figure 10. Libyan insolation & power generation by solar energy.

- Peak Sun Hours = 4.55 hours = 16380 seconds 900 W/m^2 = 900 Joules/s/m^2 (1 Watt = 1 Joule / s)
- Amount of solar energy falls on of a solar panel / day = 900 x 16380 = 1.4742 x 10^7 Joules.
- Amount of solar energy falls on a meter square of solar panel / year= 1.4742 x 10^7 x 365=5.38083 x 10^9 Joules.

- Amount of electrical energy generated by a monocrystalline panel / year= = 186.83Kwh (1Kwh = 3600 000 Joules).
- Amount of electrical energy generated by a polycrystalline panel / year= 0.11 x 5.38083 x 10^9=5.918913 x 10^8 Joules = 164.41 Kwh.
- Amount of electrical energy generated by a thin film (a-Si) panel / year= 0.05 x 5.38083 x 10^9=2.690415 x 10^8 Joules = 74.73 Kwh.

If temperature coefficient of the panel is taken into consideration:

- Electrical energy generated by a mono-crystalline panel / year= 186.83 x 0.8=149.46 Kwh.
- Electrical energy generated by a polycrystalline panel / year= 164.41 x 0.8 = 131.53 Kwh.
- Electrical energy generated by a thin film panel / year= 74.73 x 0.916 = 68.45 Kwh.
- Amount of electrical energy lost through battery and invertor is around 10 – 20%.
- Using a 20% electrical energy lost, the resultant electrical energy generated by a mono-crystalline panel, polycrystalline panel and thin film panel per year will be 119.57 Kwh, 105.22Kwh and 54.76Kwh respectively Ref. [7].

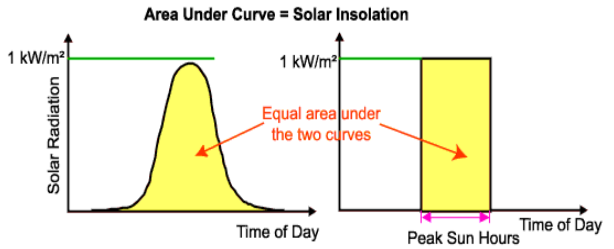

Figure 11. Peak sun hours

The average daily solar insulation in units of kWh/m^2 per day is sometimes referred to as "peak sun hours". The term "peak sun hours" refers to the solar insulation which a particular location would receive if the sun were shining at its maximum value for a certain number of hours. Since the peak solar radiation is 1 kW/m2, the number of peak sun hours is numerically identical to the average daily solar insulation Ref. [8].

Libya has the potential to become a renewable energy giant according to Responding to Climate Change. It boasts a very high daily solar radiation rate on a flat coastal plain it is about 7.1 kilowatt hours per square meter per day (kWh/m2/day) and in the south region it is about 8.1kWh/m²/day Ref. [9].

XIII. Cooling System in Solar Power Systems

This work will introduce the types of cooling in solar power and this paper will focus on the Photovoltaic (PV) solar cooling that took a place in number 4 solar air conditioning.

- Solar open-loop Air Conditioning using desiccants.
- Passive solar cooling.
- Solar closed-loop absorption cooling.
- Photovoltaic (PV) solar cooling.
- Geothermal cooling.

In this paper we have suggested that, PV solar cooling has the treatment of our problem, using a fan to cool the sub-stations. Therefore, to cool a substation from the heat that occurs from the sun we have suggested that, connecting a fan within the building of sub-station as shown below in Fig. 12 to cool the sub-station, in addition, the electricity that feeds the fans comes from the PV system, we thought that it is the ideal method of the heating which hits the sub-stations, Table II has the details of the type with measurement values of the fan.

Since PV cooling's cost effectiveness depends largely on the cooling equipment and given the poor efficiencies in electrical cooling methods until recently it has not been cost effective without subsidies. Using more efficient electrical cooling methods and allowing longer payback schedules is changing that scenario.

Figure 12. Fan for cooling substations

TABLE II. Design for the Fan (Single Phase)

Industrial extractor	
Uptocode	PSM-400
Air outlet diameter	410
Voltage	220
Power	185
Flow	4500
Transfer	1410
Weight	8,80 kg

We hope that to use it in our daily life to use it as other solution for cooling the sub-station as AC load and other stations, Fig. 13 explained the block diagram of the load side using the fan.

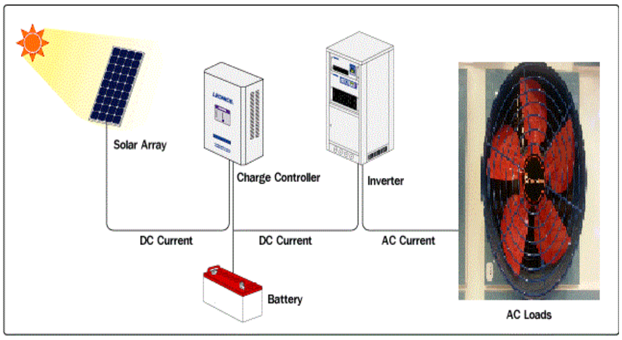

Figure 13. Simple diagram of solar power system.

Switched mode supplies can be used for many purposes including DC to DC converters. Often, although a DC supply, such as a battery may be available, its available voltage is not suitable for the system being supplied Ref. [10].

XIV. Conclusion

The objective of this paper is to cool the sub- stations using solar panels that produce electricity from the sunlight to convert DC-AC.

The D-converter circuit that is what we have used in our design by using the boost converter or as known step up switch to find the optimal solution for the ripple in the input and output as taken from the main paper of our paper that named (DC-to-DC Converter with Low Input Current Ripple for Maximum Photovoltaic Power Extraction as shown in Ref. [6]).

The simulation of using MATLAB that gave us the right result for the ripple that occurs in the circuit as shown in Fig. 14.

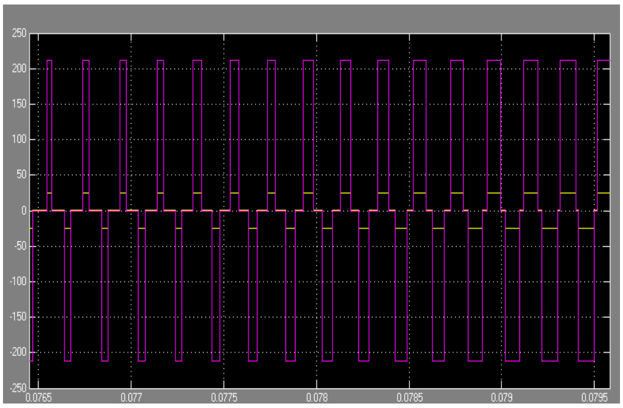

Figure 14. Simulation result using MATLAB.

Acknowlegment

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