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DC Off-Grid Solar Wind Hybrid Power for Domestic Application

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ABSTRACT: This project proposes a framework to implement a portable DC power system to supply home DC appliances. Different aspects of this solution will be described. The price on renewable energy generators such as photovoltaic panels and wind generators decreases and makes DC power system more attractive and efficient. This project also covers the design, simulation and hardware implementation of DC-DC converter used to provide DC power to a household. The proposed model is studied by using SIMULINK/MATLAB version 2013. This hybrid system supplies electricity by using domestic applications. Buck boost converters are employed in the proposed system which allows maximum power point tracking (MPPT) control to extract maximum power when it is available. An adaptive MPPT algorithm is employed.

I. INTRODUCTION

Initially DC was the power used for household but due to the advantage of AC system it has been used widely. Over the last century AC power has been the main type of power that was generated and used for residential purpose. Modern electronics use DC power as the main source of power. This makes the feasibility to use DC as our standard voltage in homes much more efficient. For a household network, the use of one or more form of the following hybrid DC generation such as photovoltaic panels, fuel cells, wind turbines, hydro generators and batteries are able to supply a low power household. Currently, power system infrastructures that wish to incorporate fuel cells and photovoltaic must first convert the DC power produced by this energy source to AC.

This adds complexity and reduces efficiency of the power system due to the need of a power converter. The application of DC distribution system is proven to be an effective method of power delivery. The losses due to the reactive power component are neglected in DC distribution increasing efficiency by reducing losses due to an increase in current magnitude for an equal amount of transferred power. AC has always been that it is easy to change the voltage up and down with transformer. As there is no need of DC transmission it is highly preferable for residential usage. The output of the PV system is not very efficient due to the varying atmospheric condition such as temperature and irradiance. Hence, to improve the performance of the PV system, the MPPT system and a DC-DC converter are employed. The MPPT system is responsible to track the maximum power point of the PV system and transfer it to load. The DC-DC converter is used to improve the strength of a source voltage.

II. PROPOSED SYSTEM

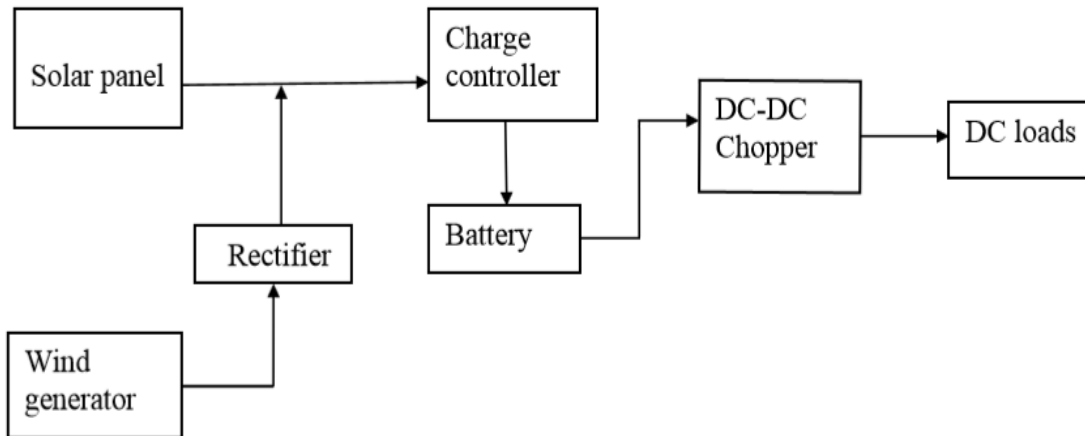
Our proposed system is a hybrid power system which combines solar and wind power with battery as a storage device. The DC power generated by the solar panel is given to the converter to which the rectified output of the wind turbine is also given. Converter converts the fixed DC to a variable DC. It also strengthens the source voltage. To improve the performance of the PV system, the MPPT system and a DC-DC converter are employed. The MPPT system is responsible to track the maximum power point of the PV system and transfer it to load.

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Block Diagram Of Proposed System

III.MPPT CONTROL FOR SOLAR PANELS

The inductor current is taken as reference and it is given to the proposed sampling strategy in that the inductor current can be sensed. After that the current value is given to MPPT strategy and voltage balancing control. In MPPT strategy perturb and observe(P&O) algorithm is used. In this algorithm a slight perturbation is introduced to the system. This perturbation causes the power of the solar module varies.

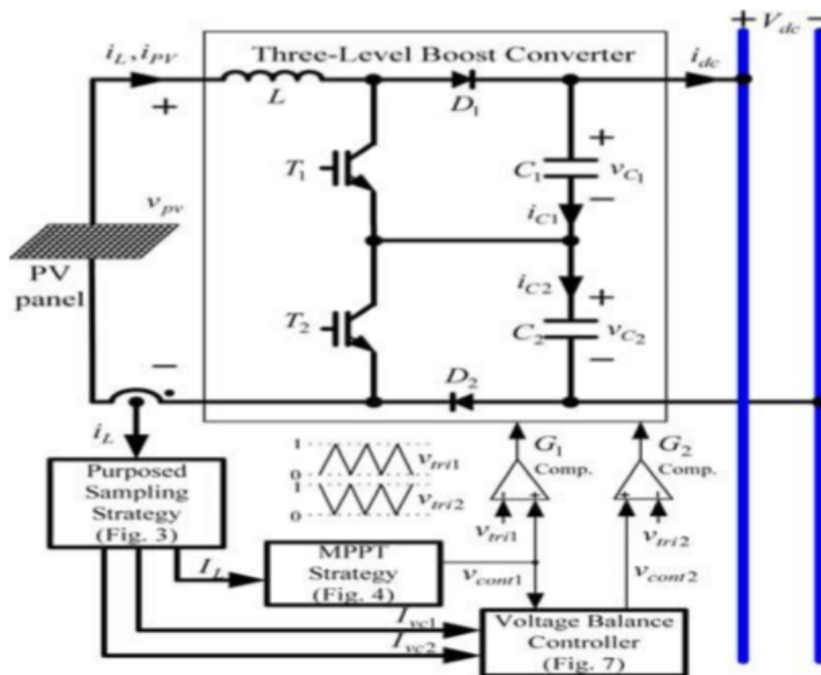


Diagram for MPPT model



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If the power increases due to the perturbation then the perturbation is continued in the same direction and if the power decreases, then the next perturbation should be in the opposite direction. Voltage balancing control is used for giving gate pulse to the MOSFET. Three level boost converters are used for voltage balance and voltage boosting. The voltage can be control by using the capacitors parallel to the MOSFET. Then the boost output is use to run the load.

When we are using two switches for boost converter we can achieve better control over the power produced by the PV panel, the output from the boost converter is given to filters or impedance network for regulation and then dc output is given to the household appliances. Both photovoltaic voltage and PV current need to be sensed to perform maximum power point tracking (MPPT) control. For three-level boost converter, both capacitor voltages need to be sensed and an additional voltage balancing control loop is required to balance the capacitor voltages. In this project, the MPPT control and the voltage balancing control with sensing only inductor current is proposed. The output voltage from the boost converter is given to the dc bus from the dc bus the loads are connected.

IV.HARDWARE REQUIREMENTS

a.Solar Power Generation

Solar power is the generation of electricity from sunlight. This can be direct as with photovoltaic or indirect with concentrating solar power (CSP).Light (particularly sunlight) can be used to create heat or generate electric power .This is referred to solar energy.

b.Solar panels

Solar panels make use of renewable energy from the sun, and are a clean environmentally sound means of collecting solar energy. Solar panels collect solar radiation from the sun and actively convert that energy into electricity. Solar panels are comprised of several individual solar cells. These solar cells function similarly to a large semiconductors and utilize a large area P-N junction diode. When the solar cells are exposed to sunlight, the P-N junction diode convert the energy from sunlight into usable energy .the more solar cells in a panel and higher the quality of solar cells, the more total electrical output the solar panel can produce. The conversion of sunlight to usable electrical energy has been doubled the photovoltaic effect .The photovoltaic effect arises from the properties of the P-N junction diode, as such there are no moving parts in a solar panel. Most system doesn't use the energy directly from the solar panel. This is because the sun is always shining. The inverter is converting DC to AC power and sending it to the load.

c.Photovoltaic conversion

Voltaic means "Producing electric current". Photovoltaic means "creating electricity when exposed to the light". A cell is a device that produces electricity. An example of an electric cell is a flashlight battery. Photovoltaic cells produce electricity when exposed to the light .They usually consists of panels. The panel contains the two layers of different materials .when light hits these two layers, one of the layer becomes positively charged, and other becomes negatively charged.

This works similar to a regular flashlight battery, which has a positive and negative end. When a wire connects a two ends, they produce an electric current. When the two layer of the material in a solar cell are exposed to light, they create an electric current.

Solar panel specification

PARAMETERS	RATINGS
Open circuit voltage	21.6V
short circuit current	0.329A
Voltage at maximum power	17V
Current at maximum power	0.29A
Maximum reverse current	1A
Maximum system voltage	1000Vdc
Nominal operating cell temperature	47 c ±2 c



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Specifications of solar panel

Factors deciding the production

- The peak power of panels.
- Light intensity.
- The number of exposure to the sun and the angle of exposure to the sun.
- The intensity of the sun.

d. Wind Power Generation

Wind power is the conversion of wind energy into a useful form of energy, such as using wind turbines to make electricity, windmills for mechanical power, and wind pumps for water pumping or drainage. A wind generator's rotating blade convert the wind's kinetic energy into rotational momentum in a shaft. The blades use energized airfoils, matched to the alternator, the capture the wind's energy. The wind output is rectified into DC and feed into the inverter. The blade must turn to face the wind, so a yaw bearing is needed, allowing the wind turbine to track the winds as they shift direction. Some sort of governing system limits the rotor rpm as well as generator output to protect the turbine from high winds. A shutdown mechanism is also useful to stop the machine when necessary, such as during an extreme Strom, when do not need the energy, or want to service the system. The total amount of economically extractable power available from the wind is considerably more than present power use from all sources. A wind farm may consist of several hundred individual wind turbines which are connected to electric Power transmission network. Offshore wind power can harness the better wind speeds that are available offshore compared to on land, so offshore wind's power contribution in terms of electricity supplied is higher. Small offshore wind facilities are used to provide electricity to isolated locations and utility companies increasingly buy back surplus electricity by small domestic wind turbines. Although a variable source of power ,the intermittency of seldom creates problems when using wind power to supply up to 20 % of total electricity demand, but as the proportion rises, increased costs , a need to use storage such as pumped – storage hydroelectricity, upgrade the grid, or a lowered ability to supplant conventional production may occur. Power management techniques such as excess capacity, storage, dispatch able backing supply (usually natural gas).exporting and importing power to neighboring area or reducing demand when wind production is low, can mitigate these problems.

V. HORIZONTAL AXIS WIND TURBINE

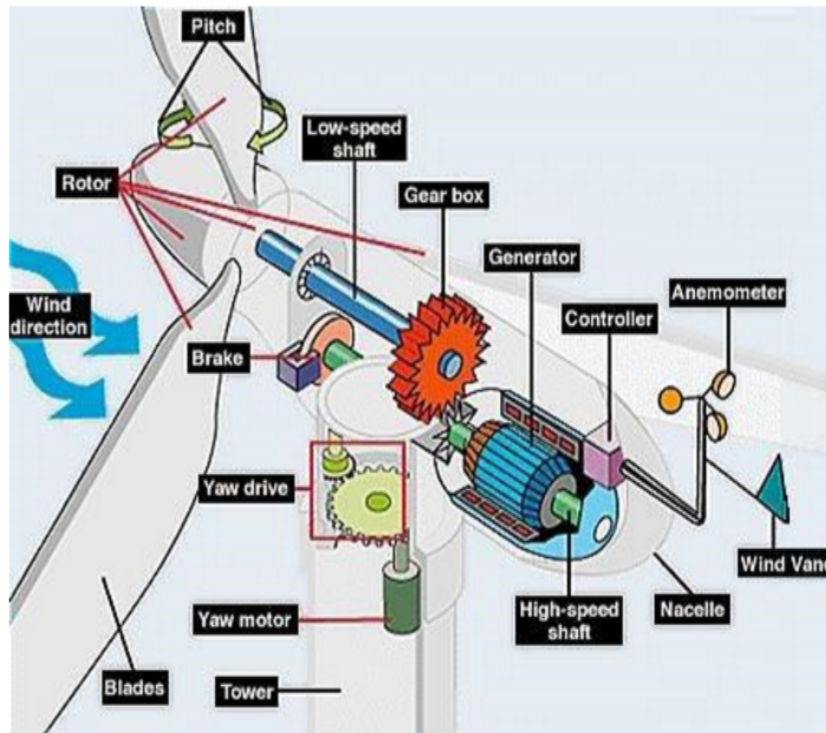
Horizontal-axis wind turbines (HAWT) have the main rotor shaft and electrical generator at the top of a tower, and must be pointed into the wind. Small turbines are pointed by a simple wind vane, while large turbines generally use a wind sensor coupled with a servo motor. Most have a gearbox, which turns the slow rotation of the blades into a quicker rotation that is more suitable to drive an electrical generator. The blades rotate at 10 to 22 revolutions per minute. At 22 rotations per minute the tip speed exceeds 90 meters per second (300 ft/s). A gear box is commonly used for stepping up the speed of the generator, although designs may also use direct drive of an annular generator. Some models operate at constant speed, but more energy can be collected by variable-speed turbines which use a solid-state power converter to interface to the transmission system. All turbines are equipped with protective features to avoid damage at high wind speeds, by feathering the blades into the wind which ceases their rotation, supplemented by brakes.

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Horizontal Axis Wind Turbine

Specification of Wind Turbine

PARAMETERS	RATINGS
Height of the Turbine	175 cm
Diameter of Turbine	0.2 m
Length of the blade	47.5 cm
Breadth of the blade	11.5 cm

Benefits of horizontal axis turbine

- Blades are to the side of the turbine's center of gravity, helping stability.
- The turbine collects the maximum amount of wind energy by allowing the angle of attack to be remotely adjusted.
- The ability to pitch the rotor blades in a storm so that damage is minimized.
- The tall tower allows the access to stronger wind in sites with wind shear and placement on uneven land or in offshore locations.



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- High efficiency, since the blades always move perpendicularly to the wind, receiving power through the whole rotation.
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- The horizontal wind is that it is able to produce more electricity from a given amount of wind.

VI. POWER CALCULATION

Wind Turbine

$$\text{Output power} = 1/2[\rho AV^3 C_p]$$

Where

A is the swept area, ($A = \pi r^2$).

r is radius of the turbine,

V is the velocity of wind,

C_p is the power coefficient ρ is the air density.

Consider Radius = 0.5m, V = 12m, $C_p = 0.4$, $\rho = 1.23$.

$$\text{Output power} = 1/2[1.23 * \pi r^2 * 12^3 * 0.4]$$

$$= 1/2[1.23 * \pi * 0.5^2 * 12^3 * 0.4]$$

$$= 333.86 \text{ Watts/hr.}$$

Solar Panel

$$\text{Output power} = VI$$

V is the voltage at maximum power

I is the current rating at maximum power.

$$\text{Output power} = 17 * 294$$

$$= 4.998 \text{ watts/hr}$$

Total power generated = 378.86 watts/hr Consider 12 hrs per day then the total energy generated in our proposed model will be equal to 4.54 KW.

VII. SOFTWARE REQUIREMENTS

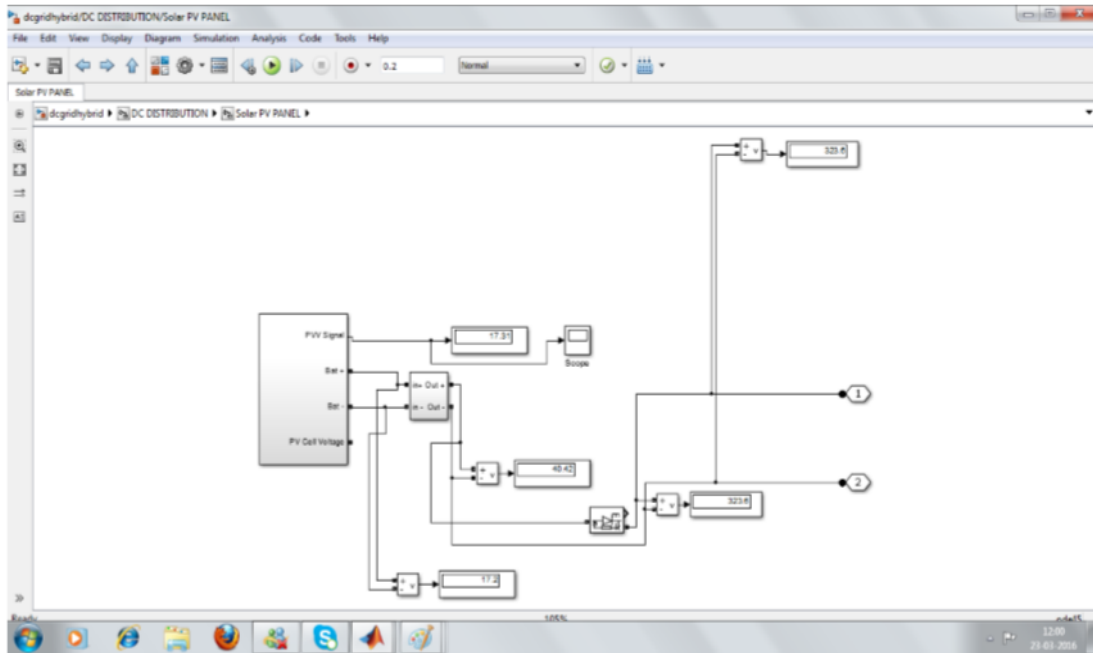
Simulink is a tool for simulating dynamic systems with a graphical interface specially developed for this purpose. Within the MATLAB environment, Simulink is a MATLAB toolbox that differs from the other toolboxes, both in this special interface and in the special “programming technique” associated with it. There is a further difference, in that the source code of the Simulink system is not open, but this is of no concern for our purposes. The goal of this chapter is to introduce simple manipulations with Simulink and to clarify the interaction of Simulink with MATLAB.

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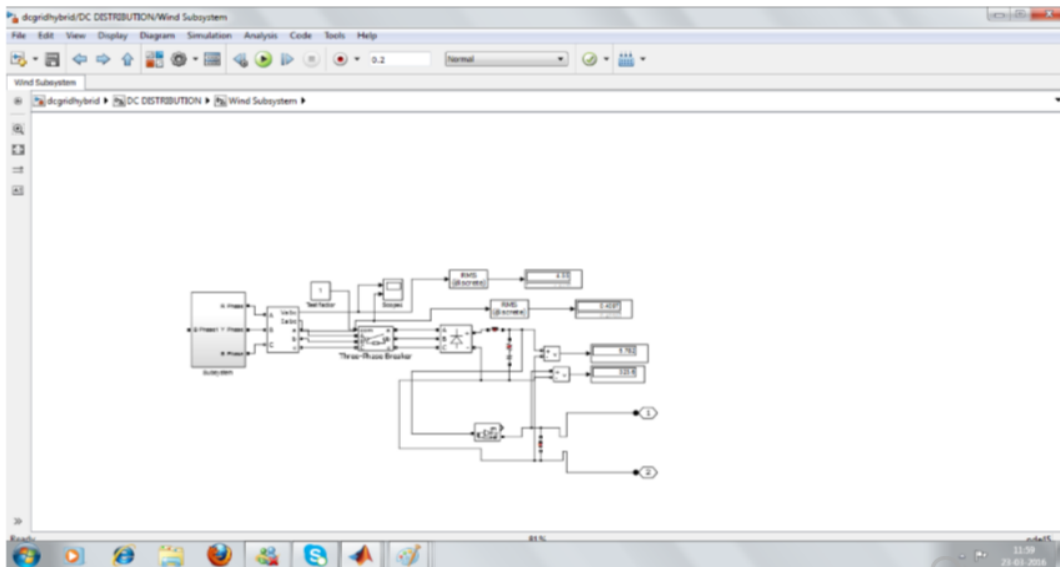
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Subsystem circuit of Solar Panel



Subsystem circuit of Wind Turbine



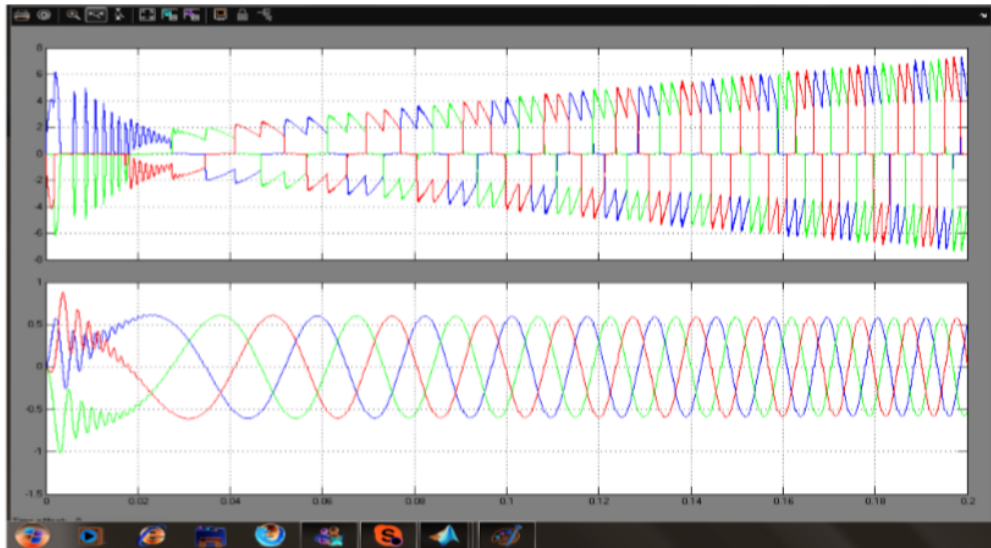
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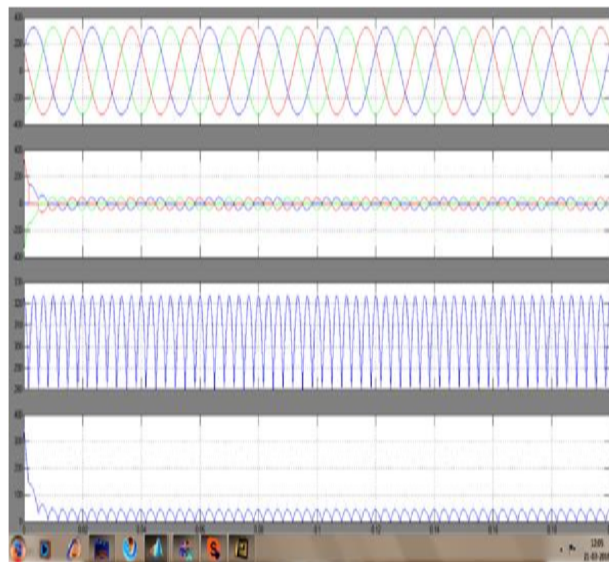
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Simulink output of wind turbine



Overall output of the DC system



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Entire Experimental Set Up

VIII. CONCLUSION AND FUTURE SCOPE

In this project we conclude that usage of DC power for domestic purpose makes the efficient use of power. The application of DC distribution system is proven to be an effective method of power delivery. The losses due to the reactive power component are neglected in DC distribution, increasing efficiency by reducing the losses due to an increase in current magnitude for an equal amount of transferred power. Thus the efficiency of DC system is increased to 25%. Upcoming years the AC system will be replaced by the DC system for domestic purpose for their efficient performance.

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