TECHNIQUES FOR

TESTING OF SOLAR SYSTEMS

System and device detailed specification

a) Solar Panel

Model	: Yingli YL250P-35b
Peak Power (P_P)	: 250W (± 3%)
Open Circuit Voltage (Voc)	: 44.1V
Short Circuit Current (I_{SC})	: 7.72A
Peak Voltage (V_P)	: 35.3V
Peak Current (I_P)	: 7.08A

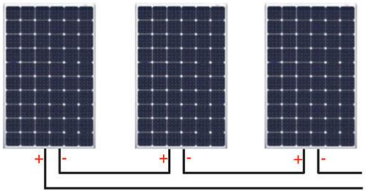

Fig 3.1 Three nos. of 250W panel connected in series

In a series circuit, the current through each of the panel is the same, and the voltage across the circuit is the sum of the voltages across each panel.

Hence Peak Voltage (V_P) = 35.3 x 3

= **105.9V**

Current remains same (I_P) = **7.08A**

Peak Power (P_P) = V_P x I_P

= 105.9 x 7.08

= **749.7W**

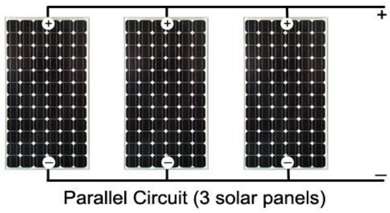

Fig 3.2 Three nos. of 250W panel connected in parallel

In a parallel circuit, the voltage across each of the panels is the same, and the total current is the sum of the currents through each panel.

Hence Peak Current (I_P) = 7.08 x 3

= **21.24A**

Voltage remains same (V_P) = **35.3V**

Peak Power (P_P) = V_P x I_P

= 35.3 x 21.24 = **749.7W**

b) Battery

Model	: First Power LFP12100
Type	: Sealed Lead Acid Battery
Voltage	: 12V
Current	: 10A for 10Hr
Ampere Hour	: 100AHr

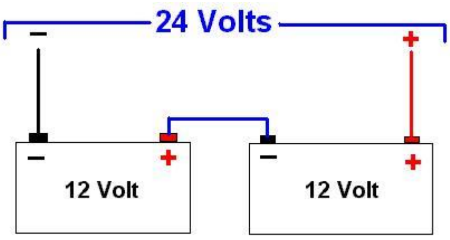

Fig 3.3 Two nos. of 12V battery connected in series

In a series circuit, the current through each of the battery is the same, and the voltage across the circuit is the sum of the voltages across each battery.

Hence **24V** for **100AHr.**

c) Charge Controller

Model	: Phocos CXN-40
Type	: Pulse Width Modulation **(PWM)**
Voltage	: 12V/24VDC
Current	: 40A

Fig 3.4 Charge controller 12v/24vdc 20A

The charge controller protects the battery from being overcharged by the solar panel and from being deep discharged by the loads. The charging characteristic includes several stages which includes automatic adoption to the ambient temperature. The charge controller adjusts itself automatically to 12v or 12v system voltage. The charge controller can be programmed for lighting applications. Additionally, it has a serial interface which can be used with an optional interface adapter.

d) Solar Pumping Inverter

Model	:	MNE-SP550V2U
Rated power	:	0.55KW
Max. Open circuit voltage	:	430VDC
Min. Open circuit voltage	:	105VDC
Max. Input current	:	13A
Output phase voltage	:	220VAC
Rated output current	:	5.5A

Fig 3.5 Solar Pumping Inverter

e) MPPT Controller

Model	:	Tracer-3215RN
System voltage	:	12/24VDC
Rated charge current	:	30A
Rated discharge current	:	20A
Max. PV Input voltage	:	105VDC
Max. PV Power for 12V system	:	390W
Max. PV Power for 12V system	:	390W

Fig 3.5 MPPT Controller

4. Testing Techniques Conducted

4.1 Analytical Method - 1

This method includes components as follows,

1. 3 nos. of Polycrystalline Silicon Photovoltaic Panel
2. 2 nos. of Battery LFP12100 (12V 100AHr/10Hr)
3. Phocos CXN-40 controller
4. 4 nos. of 12vdc bulbs

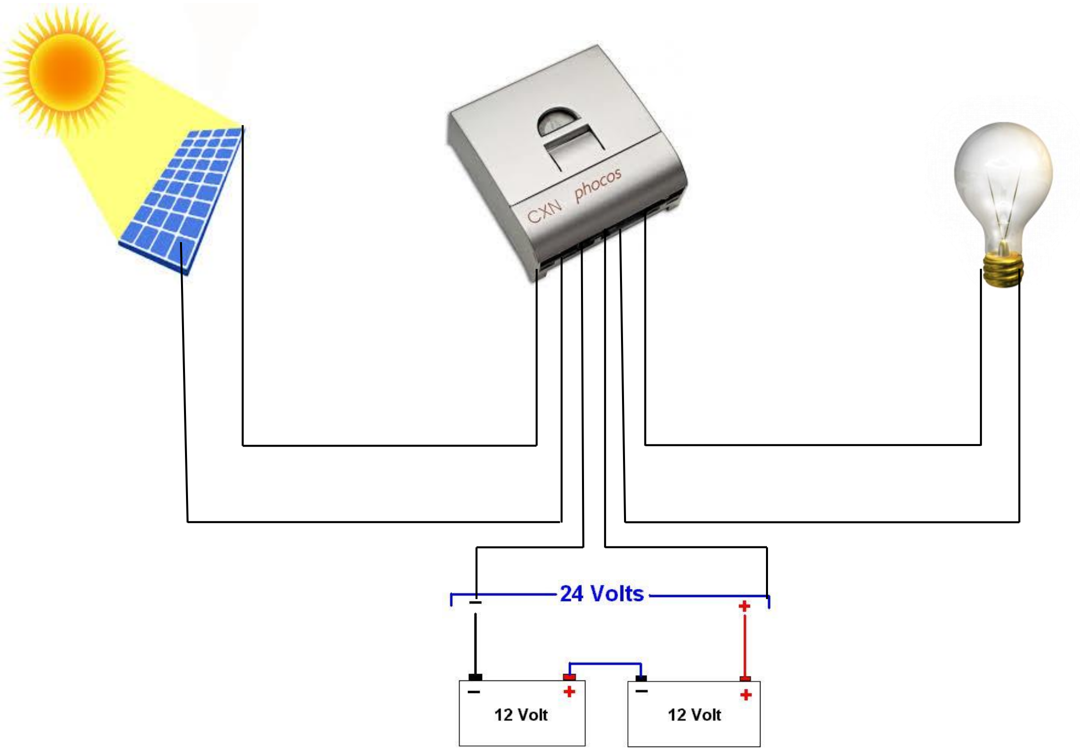

Fig 4.1 Schematic diagram of method 1 solar system

Since the whole system is 24vdc, three parallel connected solar panel (shown in Fig 3.1) is connected to the controller solar (+) & (-) terminals and two series connected 12vdc battery (shown Fig 3.3) is connected to the controller battery (+) & (-) terminals. For load (+) & (-) we connect 4 nos. of series connected 24vdc bulbs.

Calculation of power generated:

However more than 24vdc is generating from the solar panel, it converts output as 24vdc to the nominal system (battery) and current remains same. For example: During average or peak hours solar input to the controller is greater than 30v but the controller regulates 24v to the battery.

Hence individual panel peak power generated = 24 x 7 = 168W

For three parallel connected panels = 3 x 168 = 504W

Peak Hour Per day = 5 Hours

= 504 x 5

= **2,520 W/day**

Power consumption:

Five number of series connected 12w bulbs used for 24Hrs

= 5 x 12 x 24

= **1,440W/day**

Remarks:

The above analytical method was completed successfully.

Drawbacks:

The efficiency of the solar panel is largely affected because of this CXN-40 controller. However our panel can produce 35v during peak hours, we utilize 24v; there is some wastage of energy.

$$\text{Efficiency of solar panel in percentage} = \frac{\text{Output Power}}{\text{Input Power}} \times 100$$

= 168 x 100/ 250

= 67.2%

4.2 Analytical Method - 2

This method includes components as follows,

1. 3 nos. of Polycrystalline Silicon Photovoltaic Panel
2. 2 nos. of Battery LFP12100 (12V 100AHr/10Hr)
3. Phocos CXN-40 controller
4. Solar Pumping inverter MNE-SP550V2U

For this method minimum input voltage to the solar pumping inverter is 105vdc. We retain the existing method 1 connection, just change solar panel side as series (shown Fig 3.2) but the system is already connected to the controller. Accidentally the controller burnt due to high input voltage (more than 100v) from the solar, because the controller is upto 24vdc system.

Fig 4.2 Burnt Controller during method 2

After this issue we directly connect solar panel to the battery and connect load from the battery. The battery is not charging without the charge controller, load takes amps from the battery and it discharge completely.

Remarks:

The above analytical method was not completed successfully.

Drawbacks:

- CXN-40 controller burnt – Spoiled and cannot use.
- Battery drained completely until 5v – Still can use for low capacity.

4.3 Analytical Method - 3

This method includes components as follows,

1. 2 nos. of Polycrystalline Silicon Photovoltaic Panel
2. 2 nos. of Battery LFP12100 (12V 100AHr/10Hr)
3. Tracer- 3215RN MPPT charge controller
4. VAM9020 Monitoring display

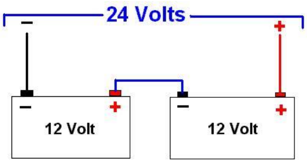

Fig 4.3 Schematic diagram of method 2 solar system

Since the whole system is 24vdc, two parallel connected solar panel (shown in Fig 3.1) is connected to the controller solar (+) & (-) terminals and two series connected 12vdc battery (shown Fig 3.3) is connected to the controller battery (+) & (-) terminals. From load (+) & (-) we connect monitoring display input, output from the meter goes to load 4 nos. of series connected 24vdc bulbs.

MPPT Technology

Maximum Power Point Tracking Technology to extract maximum power from the generated power from the solar modules. The **tracking algorithm** is fully automatic and does not require user adjustment; Tracer technology will track the array maximum power point voltage (Vmp) as it varies with weather conditions.

Current Boost

In many cases, Tracer MPPT technology will "boost" the solar charge current. For example, a system may have 8 amps of solar current flowing into the tracer and 10 amps of charge current flowing out to the battery. **The tracer does not create current!** Rest assured that the power into the tracer is the same as the power out of the tracer, since power is the product of voltage and current (volts x amps),

- Power into the tracer = Power out of the tracer
- Volts In x Amps In = Volts Out x Amps Out

If the solar module's Vmp is greater than battery voltage, it follows that the battery current must be proportionally greater than the solar input current so that input and output power are balanced. The greater the difference between the maximum power voltage and battery voltage, the greater the current boost. Current boost can be substantial in systems where the solar array is of a higher nominal voltage than the battery.

Calculation of power generated

During peak hours solar input to the controller is 34v.

Hence individual panel peak power generated	= 34 x 7	= 238W
For two parallel connected panels	= 2 x 238	= 476W
Peak Hour Per day	= 5 Hours	
	= 476 x 5	
	= **2,380 W/day**	

This MPPT controller is capable of produce power during whole daytime during sunny days (i.e. from 8am to 6pm).The above calculation is only for peak hours.

Power consumption

Five number of series connected 12w bulbs used for 24Hrs

= 5 x 12 x 24

= **1,440 W/day**

Remarks

The above analytical method was completed successfully. Efficiency of the solar panel is largely increased by using MPPT controller when compared to CXN-40 controller.

$$\text{Efficiency of solar panel in percentage} = \frac{\text{Output Power}}{\text{Input Power}} \times 100$$

= 238 x 100/ 250

= 95.2%

Drawbacks

- The peak voltage of a solar module decreases as the temperature of the module increases.

5. Future Scope of Works

In future we are going to conduct new analytical method by connecting dc pump as load to the controller and 3 nos. of parallel connected solar panel input to the controller. By succeeding this method, we drifting towards “off grid” dc pump system for home-based applications.

6. Conclusion

Solar energy has many direct uses, including domestic and industrial applications such as decorative lighting, home lighting, industrial lighting and pumping system etc. Solar photovoltaic (PV) cells can generate electricity on a small or large scale. In addition, PV cells are used in a variety of cost-effective and “off the grid” applications, including calculators, wrist watches, road and railroad warning signs, telecommunication equipment, flashing school zone lights and emergency lighting on offshore oil rigs. Solar energy is an inexhaustible renewable resource. The sun constantly produces vast amounts of renewable solar energy that can be collected and converted into electricity.