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PV Solar System for Stand Alone House with Smart Inverter

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ABSTRACT:
Now a day's Renewable energy is an essential element it is comes from naturally or climate change. The advance technology helps for energy storage is increases the installation of solar system for residential houses. Here we using photovoltaic (PV) solar system for a sustainable house. This paper gives the information about effect use of solar energy by using advanced technology. Here inverter plays a major role for this entire system. Inverters are mainly classified into two types one is single level inverters and another one is multilevel inverters. Multilevel inverter has major advantage comparing to single level inverter. It can be reduced the harmonic distortion and also main advantage in multilevel inverter it reduces the EMI (Electromagnetic Interference) generation. This type of inverters can be operates in various voltage levels. For inverter controlling purpose we using PWM (pulse-width modulation) controller.

Index terms: Stand alone PV system, charge controller, battery, inverter, microcontroller, sensor.

INTRODUCTION:

For reducing the greenhouse gas by emissions we majorly prefer to choose Renewable energy sources. Solar system is the one of renewable energy sources it can be reducing the production of carbon dioxide. Solar electrical system can be implemented in two types or forms.

- Grid connected systems.
- Stand alone system.

The knowledge about both stand alone and also grid connected system, It can utilises for most cases in the inverter (DC to AC) to the household equipment. The stand alone system utilise an inverter through power the household equipment using the energy from the PV (photovoltaic) solar system and also the installed batteries. The system consisting of the following:

1. Charger controller
2. Inverter (DC to AC)

The inverter introduces the additional system losses with maximum efficiency at rated power. The system can be operated at rated power for short period (4 hrs to 6 hrs) during the day and remaining time the system can be operated at less than half (50%) of the inverter rated power. Here we are using smart solar inverters for effective utilisation of energy and reducing the loss and wastage. Smart solar inverter means it have a digital architecture which is used for bidirectional communication. These system we used an efficient and rugged silicon centric hardware. It can be controlled by using scalable software which has a performance of modern monitoring capability. This inverter has a major property able to receive and sending messages fastly and also share the data with owner. Such systems allow maintenance issues like prediction problems and service technicians to operation. This power electronics device includes software which is API (application programming interface) its functionality is to provide information to owner and other partners.

2. SOLAR PANEL (Flat Plate Collector):

Flat plate collector is a metal (Aluminium) box with a Plastic cover or glass on top and on the bottom side dark coloured absorber plate. Bottom plate acts as a collector it is usually insulated to minimize the heat loss. Sunlight passes through the plastic cover (glazing) and strikes into the absorber plate, which is heats up and changing or converting heat energy into solar electrical energy. In absorber plate piles are fixed which is used for heat transfer to liquid. These plates are commonly painted or coating with selective coatings, which absorbs and retains heat better than the ordinary black colour paint. Absorber plates are made up of copper or aluminium metals, because this metal has a good heat property. Copper is more expensive comparing to aluminium, but it is better conductor and also less prone to corrosion. The below Fig (1) shows the flat plate collector.

Fig 1. Solar panel

3. DESIGN CIRCUITS:

3.1 Design of Stand Alone Solar PV System

Electrically the stand alone PV system is not connected. These systems are used to meet the electricity demand or needs of standalone houses and farm houses which are located at remote areas. The schematic design of the stand alone solar PV system is shown in below Fig (2).

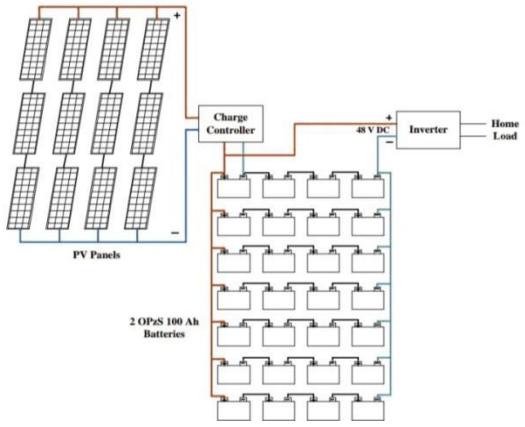

Fig 2. The schematic of the stand alone solar PV system

The energy required of the system is to be provided by PV panels. The energy which has generated from the solar PV panels can be stored in batteries. DC energy which is stored in the batteries is converted into AC energy by the inverter. When the solar radiation is not available in night time or when it inadequate, the energy required for the system is providing directly from the batteries. The components used for balancing the system components are called as BOS (balance of system) components. BOS (balance of system) components are nothing but charge controller, inverters, batteries, cables, fuses or protecting equipment etc. It is important to determine where the system will be installed before the system can be designed. Solar radiation differs from region to region on a daily, monthly and seasonally. For this reason, these systems are designed by meteorological information or average annual sunshine duration.

3.2 PWM Technology

PWM (Pulse width modulation), is a modulation technique which is used to Converts a message into pulsing signal and also this technique is used to encode information for the transmission. The advantage or use of PWM is to allow the control of a power supplied to electrical device. PWM (Pulse width modulation) is one of two principal algorithms used for PV (photovoltaic) solar battery chargers.

The average output value of both voltage and current feding to the load is to control by turning ON or OFF the switch in between the supply and load. The switch is on comparing to the off period for supplying the higher power to the load. The switching frequency PWM is much higher than the load which results the waveform perceived the load must be smooth as possible. Based on the load switching is done several times (Hz or KHZ or MHZ). Duty cycle describes the ON time to the regular interval of time and low duty cycle correspond to the low power, because the power OFF time is more. The main advantage for considering PWM (Pulse width modulation) is that has less power loss in switching devices. When switch is OFF there is no current transferred through the load and when switch is ON there is a current transferred to the load. PWM is also works with digital controls, which because of their ON and OFF nature. We can easy to set the needed duty cycle as per our requirement. PWM also be used as communication systems and also its duty cycle can be used for convey information.

3.3 IR Sensor

It is an electronic device it emits in order to sense aspects in the surroundings. An IR sensor can be detects the motion and also it measures the heat of an objects. The circuit shown in below Fig (1).These sensors measured only infrared radiation. In the infrared spectrum the objects radiate some type of form of thermal radiation. This types of radiations are not invisible for our human eyes that can be only detect infrared sensor. The emitter here used an IR LED and the detector used is an IR photodiode which has sensitive to IR light and also same wavelength it is emitted by the IR LED (Light emitting diode). When the light falls on photodiode, the output voltages and resistance, will change in its proportion to the magnitude of the light received. An IR (infrared) sensor circuit which is basic and most popular sensor in electronic devices. This sensor is help to analogous humans visionary senses, which can be used for detection obstacles. This circuit having following components

1. LM358 IC 2 IR transmitter and also receiver pair
2. Resistors used in the range of (Mega ohms or kilo ohms).
3. Variable resistors
4. LED :- Light Emitting Diode

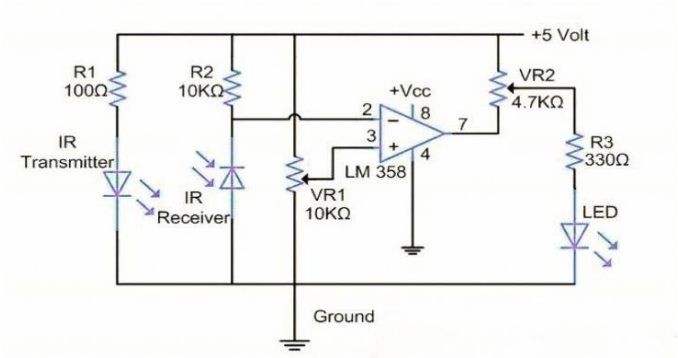

Fig 3. Circuit of IR sensor

3.4 Power Saving

The main objective for using this technique is to make or design a microcontroller based model which is used to count the number of persons visiting in a particular room and accordingly it automatically light up the room. Here we use IR sensor and it can detect present number of persons. Now a days there is a continuous use of automatic appliances. There is a need for developing circuits that can be ease to reduce the complexity of life and also every one wants to know how many people or persons present in room so as not to have crowd. This circuit can be proves to be more helpful. This technique of Light Automation using the Bidirectional Visitor counter using a Microcontroller is reliable circuit that takes total task of controlling of the room lights and also counting number of people or persons in the room accurately. When somebody or some person enters into the room then the counter can be starts counting and incremented by one. Here we have extended the project by placing a LM35 or temperature sensor which is used to monitor the room temperature and based on temperature level when it is high it can turn ON fans and temperature is low it can OF the fans. These processes can be done by automatically and also manually. It can display the total number of persons inside or present in the room is also shows in the LCD.

The microcontroller do the above job. It can be received the signals from the sensors and also this signal can be controlled by the software and storage in RAM (random access memory). The 89s52 (Microcontroller) is continuously monitor the IR (Infrared Receivers). When any object can be moved through the IR Receivers then the IR Rays will be falling on the receiver that can be sensed by the Microcontroller.

3.5 Power Saving Block Diagram

IR (Infrared sensors) are a type of light sensors that having a function of infrared part of frequency spectrum. IR sensors are a active sensors which consist of a Receiver and also emitter. When the beam or light is cut the controller it know if the person is entering or leaving and then accordingly increment or decrements the counter which is counts is displayed on the LCD screen. If there are no people or persons in the room the controller will automatically turns OFF the power supply in the room as well as if some persons present in the room it will automatically turn ON the power supply. Since these controller is automatically turns ON or OFF the relay using a as relay driver circuit. The ADC (Analog to Digital converter) is used to monitoring the room temperature and accordingly Turn ON or OFF the lights and fans Power Saving Block diagram shown in below Fig(4).

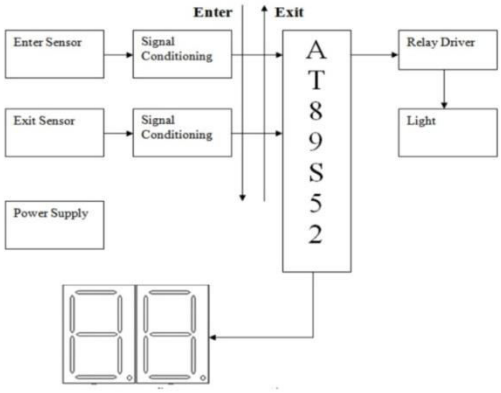

Fig 4. Block diagram of Power saving

3.6 Microcontroller Circuit (AT89S52)

Here, we used AT89S52 microcontroller which has a low-power high performance CMOS (Complementary Metal Oxide Semiconductor) 8 or 16 bits with 8K bytes of system programmable Flash memory. This device can be manufactured using Atmel's non-volatile memory technology. The on chip Flash allows the program memory for the conventional non-volatile memory programmer. In system programmable Flash and monolithic chip are combined for versatile 8 bit CPU. The Atmel AT89S52 is one of the powerful microcontroller which provides the effective solution for many embedded control application and also it is highly flexible. This micro controller provides the following features: 8Kb of Flash, 256 bytes of RAM, 32 input/output lines, Watchdog timer, 2 data pointers, 3 16bit timer/counters, a 6vector 2 level interrupt architecture, full duplex serial ports, ON chip oscillator, and also clock circuitry. In addition, these microcontrollers (AT89S52) is designed with a static logic for the operation down to zero frequency and also supports with two software selectable power saving modes. The Idle Mode is stops the CPU while allow the timer/counters, RAM, serial ports, and interrupt system to be continue functioning. The Power down mode will saves the RAM contents can freeze the oscillator more and also it can be disabling all other chip function until next interrupt reset. The circuit diagram of microcontroller circuit shown in below Fig (5).

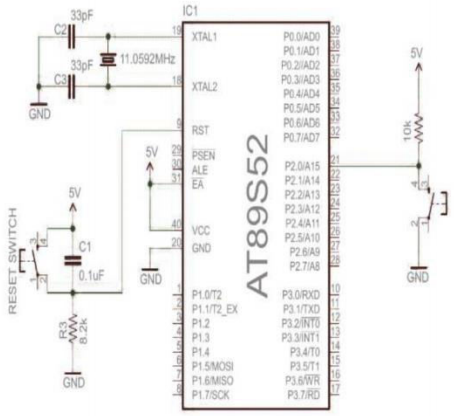

Fig 5. Circuit diagram of Microcontroller circuit

4. Determination of System Components:

4.1 Load:

The first step in this system designing is to calculating the average amount of per day energy or daily energy that the stand alone house will be consumed. Below Table 1 shows the household equipments or devices and the amount of energy that will be consumed. The calculations which are done by taking some assumption that the devices are used at home applications are energy saving.

Table-1: Energy consumption of household appliances

Household Appliances	Number	L1 Rated power(W)	L2 Adjustment Factor	L3 Adjusted Power(W)	L4 Daily Usage (hours /day)	L5 Energy Cons. (Wh/day)
LED Lights (15W)	8	120	0.9	134	6	800
Television	1	100	0.9	112	8	896
Refrigerator	1	100	0.9	112	6	672
Washing machine	1	700	0.9	778	0.6	467
computer	1	120	0.9	134	2	268
Dishwasher	1	1200	0.9	1333	0.4	533
Other appliances	-	1750	0.9	1944	1	1944
Total	-	4090	-	4547	-	5580

The L1 in the Table 1 which is shows the rated of power values of the household appliances. The sum of those values give the total maximum AC power value of household equipments is (4090 W). The value in L2 column is adjustment factor and also related to inverter efficiency (0.90). The L3 value was calculated by dividing the L1 value to L2 value and then sum of these value will gives the maximum DC power value which is 4547 W. The per day operating hours of appliances are shown in L4. Daily operating hours calculated by considering that devices such as dishwashers and washing machine are operated one or two tines in a week. The values in L5 which are calculated by multiplying the L3 value by L4 value. The uptained value is 5580 Wh.

4.2 Battery Sizing and Selection of Battery Type

In standalone power systems there is a use of batteries in night time or where the solar radiation is low and when the solar radiation level is very low or not adequate. Generally, we are using lead acid batteries. Here we used instead of lead acid batteries we preferred OPzS batteries and It has a long life

span nearly (15 to 20 years).It require less maintenance and discharged slowly up to 80% of its rated capacity. These batteries are effective for stand alone solar PV applications. Battery autonomy can be taken into account when we calculating the number of battery in the system. This value changes from region to region. This value will be chosen by using the meteorological information and also taking the bad weather conditions. The battery calculation values are given in below Table 2.

Table-2: Calculation of battery values

A1 Battery Bus Voltage (V)	**A2 Daily Capacity (Ah)**	**A3 Days of Autonomy**	**A4 Depth of Discharge (%)**	**A5 Battery Efficiency (%)**
48	116	4	80	91
A6 Required Battery Capacity (Ah)	**A7 Capacity of Selected Battery (Ah)**	**A8 Voltage of Selected Battery (V)**	**A9 Number of Batteries in Parallel**	**A10 Number of Batteries in Series**
638	100	12	7	4

According to the total power value of L1 in table 1. the battery voltage in A1 of Table 2 can be determined as 48 Volts. The total per day capacity of A2 is calculated by dividing the per day energy amount calculated in L5 in table I by A1 value. The number of autonomy days was selecte 4 days which is A3 value. OPzS batteries can be discharge up to 80% of its rated capacity. For this A4 is chosen as 0.8 and A5 is 0.91 efficiency of the OPzS battery. The value of A6 can be calculated by using below equation.

[(A2*A3) / (A4*A5)]

The standard voltage of OPzS batteries are 12 Volts. For the values of A7 and A8, 2 OPzS with 100 Ah 12 Volts can be selected. The number of batteries which are connected in parallel in the system (A9) was found by dividing the A6 value by A7 value. The number of batteries which are connected in serial in the system (A10) was found by dividing A1 value to A8 value. According to the above calculations in Table 2, A total of 28 batteries can be selected, 7 can be connected in parallel and 4 can be connected in serial. Since, the batteries are such property of chemical products which are affected for temperature and it cause to reduction of efficiency and lifetime of batteries. These batteries was placed away from the operating areas and also at proper room temperature of 25 °C.

4.3 Solar PV Panel Sizing and Selection of PV Panel Type

The sun rays do not reach the PV panel directly due to movement of sun during the day. Maximum power can be taken from solar PV panels by tracking the solar using 1 or 2 axis solar system. These systems are very costly and complex. Due to this reason they are not much preferred. Instead of these we are using systems which are mounted top of the roofs with a fixed angle are preferred. These system can be operated in annually. For the design of the stand alone house at the we fixing the solar panels with an tilt angle of 40°. Angle will be provided by using stands for placing PV panel. The values for PV panel calculation are shown in below Table 3.

Table-3: Calculation of Solar PV panel values

S1 Annual Optimum Tilt Angle	**S2 Efficiency of BOS**	**S3 Required PV Panel Output (Wh)**	**S4 Voltage of Selected PV Panel (V)**	**S5 Power of Selected PV Panel (W)**	**S6 Average Sunshine (h)**	**S7 Energy Output Per PV Panel Per Day(Wh)**
40^0	0.87	6414	15.93	90	6.6h	594
S8 Derating Factor	**S9 Panel Energy Output (Wh)**	**S10 Total Number of PV Panels**	**S11 Number of Series Connected PV Panel**	**S12 Number of Parallel Connected PV Panel**	**S13 Nominal Rated PV Panel Output (W)**	**S14 Nominal Rated Array Output (W)**
0.9	535	12	3	4	100	1200

Considering the annually use of the stand alone house, it is appropriate to placing PV panels on the top of roof in horizontally with an angle of 40° (S1). 5.58 kWh energy calculated in L5 column is the per day total energy of the house. The efficiency of BOS component in S2 value as 0.87. The amount of energy (S3 value) that will be obtained from the PV panels per day is found by dividing L5 by S2. A 100 Wp PLM-100P/12 model polycrystalline PV panel is used for this system. The solar PV panel data is shown in below Table 4.

Table-4: Electrical data of solar PV panel

Electrical Data of PV Panel	**Values**
Maximum Power Point Voltage (V)	17.7
Maximum Power Point Current (A)	5.65
Maximum Power (W)	100
Open Circuit Voltage(V)	22
Short Circuit Current(A)	6.21

Solar PV panels will not operates at MPP (maximum power point) in every time. The values in below Table 4 can be obtained from the PV panel under STC (standard test condition) at 25 ^{o}C temperature and1000 W/m2 solar radiation with 1.5 air mass. When the STC (standard test condition) changes the values obtained from the solar PV panels also change. Therefore, S4 and S5 values were obtained, assuming that there is a10% of loss. By multiplying the maximum voltage and maximum power values of the solar panel by 0.9. Since, the system is to be considered to operate throughout the year. The average sunshine duration in any place is 6 hours which is the B6 value. The amount of energy was produced by a PV panel per day is found by multiplying S5 and S6 values. This factor (S8) is multiplied by the S7 value and S9 value is calculated, which is actually the amount of energy that is PV panel generate. For finding the total PV number in the system the value of S3 is divided by S9 value and it was calculated 12 PV panel required for this system. The system battery bus voltage is uptained or calculated as 48 V (A1 value). Since the voltage to be produced by the solar PV panel is 15.93 V (S4), the PV panels number that should be connected in series with the system is calculated by A1/S4. The number of PV panels should be connected in parallel it will be found as 4 by S10/S11.

4.4 Charge Controller and Inverter Sizing

Charge controller can be protected to the batteries from being over charging and also over discharge by regulating the voltage and current obtained from solar PV panels. It can be provides the maximum power for transfer from PV panels. One of the most important factors that can be taken in the account for determine the appropriate charge controller to the system. This charger controller can be durable to the maximum current and with compatible of bus voltage 48 Volts. Battery voltage and charge controller must be 48 Volts. Rated current of the charge controller can be calculated by using below Equation:

$$I_{controller} = S12*I_{SC}*k$$

In this designed system, PV number connected in parallel with (S12), short circuit current which is determined by the PV panel is (Isc=6.21Amps) and this current which is calculated can be multiplying the coefficient of 1.25 for the protection or security (k) is found 31.05 Amps. Values of 40 Amps or 60 Amps can be selected according to this calculated current value. In this case, charge controller with the value of 48Volts and 40 Amps to 60 Amps system to be used. Since the devices or appliances used in houses are operated in Alternating current (AC). The conversion process of DC to Ac is carried out by inverter. Many inverter systems can be used for stand alone systems. The main disadvantage this systems is if any fault occuring in the inverter will affects the whole system operation. When we calculating the power rating of the inverter must be considering that all the appliances in the house can operated at the same time. Some inductive loads such as washing machines, refrigerator and dishwasher such appliances are considered for over currents during the initial operation. Therefore, calculating the inverter rating the values that can be obtained by multiple the coefficient of 1.25. For the calculation of input power of the inverter is given in below Equation.

$$P_{inverter} = L3_{total} * 1.25$$

The minimum power of inverter needed form the system will be approximately equal to 6 kW. In this system the power.

CONCLUSION:

In this paper, the calculations of the required equipment which is used to meet the energy demand of a standalone house using only solar PV system. Some factors like per day or daily average sunshine duration, optimum tilt angle, number of autonomy days and also efficiency of BOS components etc.. The major information about the designing and also selection of the components used in this system is given. Significant role of inverter is to providing AC (alternate current) supplies at the time of power requirement to the primary uses. It can be converts DC (direct current) to AC (alternating current) and also it has efficiency about 0.95. Effective use and smarting the inverter operation we using IR sensors. Basically the use of IR sensor saves the power or reducing the wastage of power and that can be utilized in future. The application of this system is to be increased becoming more popular. Therefore, this study of this solar energy applications which can be more useful in the future.

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