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Solar Based Net Metering and Lighting System

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Abstract: This project report presents the work related to design and implementation of 1KW Solar Roof Topon Electrical lab of NIT College. In this project our aim is to get brief knowledge about installation of solar roof top of 1kw and its application.Consuming large energy via community centres, institutes, offices, etc. results in spendinghuge sum of money to power corporation everymonth. Thus, by implementing Solar Rooftop System, we can reduce the electricityconsumption from the outside source.

For the first part of net metering, the efficiency of power distribution at reduced cost to the consumers can be further enhanced by introducing a two-way billing system so called net-metering which has the potential to overcome issues such as voltage regulation, power blackouts, overstressed grid and need for expensive storage systems thereby making it beneficial for the grid and the end user.

For the second part, in the Arduino based solar lighting system- This work is about automation of street lighting systems and efficient application of street lights. Energy loss takes place due to street lights which consume enormous electric energy. In the present study, smart street lighting systems are developed to ensure efficient street lighting and reduce consumption of electric energy. Auto intensity light control helps in dimming the street lights when no movement is detected using infrared sensors. Design of such systems which have efficient applications do not only achieve energy saving but also extends the service life of street lighting equipment.

***Key Words*:**Solar Energy, Rooftop, Net metering, Arduino, LED, Street lighting system.

Introduction: In the present situation due to scarcity of non-renewable energy sources, renewable energy sources are having more importance. The net metering based solar roof top projects facilitates the self-consumption of electricity generated by the rooftop and allows for feeding the surplus in to the network of the distribution licensee. Here the type of ownership can be self-owned. In self-owned, the rooftop owner who is also the electricity consumer for the utility installs the rooftop solar system. The electricity generated is first used by owner and then excess solar power generated is fed in to the grid through net meter, which is bi-directional energy meter capable of registering both import and exported energy. Thus there is combine of captive consumption and exchange of power with utility. This net generation is then credited to owner's account and adjusted against imports from the grid.

The metering protocol for 'Grid connected rooftop solar PV system without storage' and location of solar meter and consumer meter shall be in accordance with the schematic diagram as shown in fig[1]. Basically the consumer now has two sources available to power there loads. Where the inverted SPV power line and a line from grid are connected at a junction in consumer load panel. SPV power is inverted and synchronized by using grid tie solar inverter which has the built in disconnect feature in order to prevent islanding in the distribution network when grid shuts off. The unidirectional AC solar meter is connected to the grid tie inverter output for measuring the amount of SPV generation and a Utility meter is connected at incoming point of the grid power line. Depending upon the power consumption of the consumer andthe SPV generation,direction of power flow inbetween consumer load panel and distribution network.

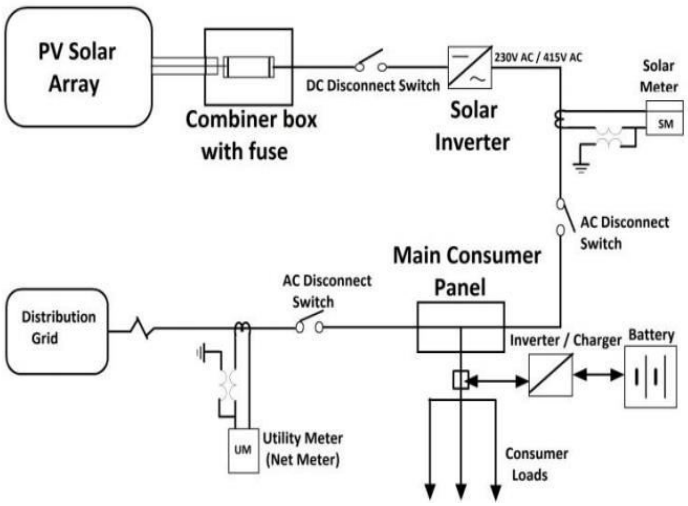


Fig 1: Net Metering arrangements

Most of time we see street lights are ON even after sunrise thus by having an smart system which turns ON and OFF street lights of given time or when ambient light falls below a specific intensity. In our project we are using motion sensors i.e. IR sensors which detect the motion of the object passing through it, using this motion of object LED's are turned ON using Arduino

Methodology: The functional block diagram of proposed net-metering concept is as shown in figure [2], and each blocks are described below.

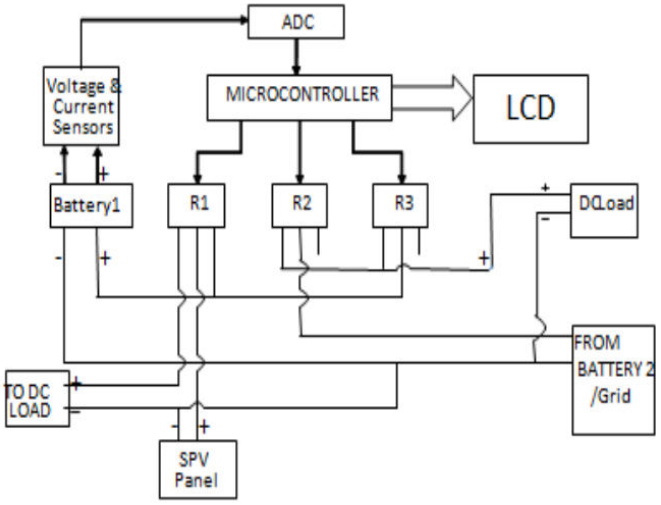


Fig-2: Block diagram of proposed net metering

a. Solar panel: It is a packaged assembly of solar cells, also known as photovoltaic panel. The solar panel can be used to generate and supply electrical energy when exposed to sun light. The generated energy is DC in nature. In the proposed project 21V, 0.3A solar panel is used.

b. AC power supply:AC to DC adopter has been used to get 12V DC input to PIC development board. The AC input i.e. 230V from the main supply is stepped down by transformer to 12V and then it is fed to rectifier. The output from rectifier is not pure DC, it is pulsating in nature and also consists of some ripples. In order to get pure DC voltage, the output of rectifier is fed to a filter to remove AC components even after rectification. Filter circuit employs electrolytic capacitor in order to remove AC components. Now output voltage is 12V given to voltage regulator to obtain constant DC voltage.

c. Lead acid battery: The battery is a device which converts chemical energy into electrical energy and vice versa. Batteries operate by converting chemical energy into electrical energy through electrochemical discharge reactions. Lead acid with sealed maintenance free battery is used in this work. And it can be used when there is absence of sun in cloudy weather. It is of 12V chargeable battery with capacity of 7Ah.

d. Microcontroller PIC18F4520: It is low power high computational performance at an economic price. It has operating voltage range of 2.0 to 5.5. It is 16 bit microcontroller with 32K bytes of flash programmable and 256K bytes of EPROM. Writing or erasing program memory will cease instruction and fetches until the operation is complete. The program memory cannot be accessed during the writing or erasing, therefore code cannot be execute. The data EPROM is a non-volatile memory array, separate from the data RAM. The program for calculation of power and energy has written and also relay operation is controlled by dumping the program into microcontroller.

e. Relays: Relay is an electromagnetic device which is used to isolate two circuits electrically and connect them magnetically. It consists of a primary coil and two contacts, normally open contact 'NO' and other is normally closed 'NC' and another one is common. When relay is in off condition the common is connected to normally close (NC).Whenever sufficient flux is produced common is connected to normally open (NO). In proposed work 12V, 10A single pole double trough (SPDT) relay is used.

Operation: The ACS712 current sensor is connected in series and voltage divider across solar panel measures the generated current and voltage respectively, and further these signals are given to PIC18F4520 microcontroller. Similarly voltage and current sensor is connected at line from which utility supply is taken, measures the amount of voltage and current drawn from utility. In proposed experimental set up battery2 indicates the utility as we considered for DC operation. Microcontroller is programmed in such a way to calculate power and energy and displayed in 20X4 LCD (Liquid Cristal Display). For the switching operation of relay reference battery voltage has to be taken. The

reference voltage is taken as 11V and the capacity of the battery taken is 12 V. Let consider the following conditions for operation of proposed circuit fig [2].

i. If solar is present and battery1 is fully charged: In this condition, since battery1 is fully charged the microcontroller will send three signals to operate relays in such a way that, relay1 (R1) is ON, extra energy generated is send to Utility (in proposed model it indicates battery2). Relay2 (R2) is in OFF state supply from utility is disconnected. And relay3 (R3) is ON indicates battery1 is input to for appliances usage.

ii. Solar is present and battry1 is not fully charged: In this condition, since battery1 is not fully charged its voltage is below reference voltage. At this condition microcontroller sends signals in such a way that, R1 is kept as OFF and battry1 is charged by solar. Now there is no sufficient energy to utilize hence need of energy from utility, and by keeping R2 ON supply from utility (battery2) is given to loads. At this moment R3 is OFF.

iii. Solar is absence and battery1 is fully charged: Since battry1 level is above reference voltage, microcontroller sends signal to R1 to operate hence Extra energy generated is transferred to utility(battery2). R2 is in OFF position as there is no requirement of energy from utility. R3 is in ON state for utilization of generated energy.

iv. Solar is absent and battery1 is not fully charged: If solar is absent obviously there is no generation of energy and R1 is in OFF mode. R2 operates, supply from utility (battery2) is taken. R3 does not operate (OFF) and it is open circuited.

Flow Chart: The flowchart of the proposed concept is shown in fig (3). Here wheneverthere is solar energy, then battery1 is get charged and if there is n solar energy loads are connected to battery2 (grid). During charging of battery1 it will check whether battery is full or not, if not then it will send signal to check availability of solar. If battery is full then excess amount of energy is sold to grid.

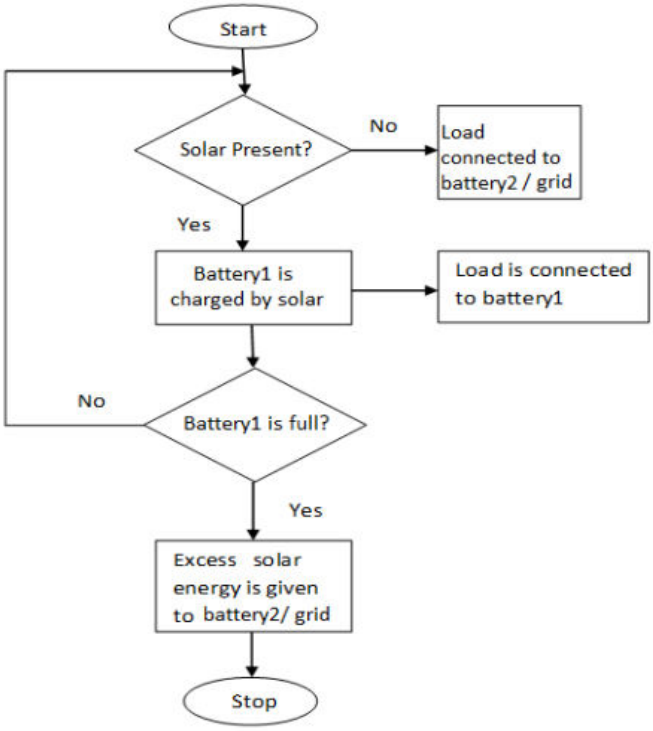
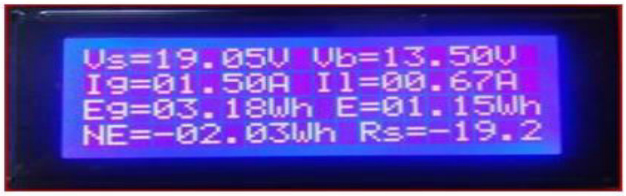


Fig 3: Flowchart of proposed net-metering concept

Results

The proposed model is designed to operates in two modes. In the following LCD displays, Vs is source energy i.e, solar energy generated. Vb is battery voltage, Ig is generated current and Il is load current. Eg indicates total generated energy in terms of Wh and E is consumed energy. NE indicates net energy of difference between generated consumed and energy. If NE is negative then it indicates that energy is buying from utility grid and if it is positive then selling energy to grid(battery2).



Arduino Based Solar Street Lighting System:

In this project, basically solar panels are used to charge batteries by converting sunlight into electric energy, reflecting below block diagram we can see that charge controller circuit is used to control charging. This

project works on principle of solar cell. This project is designed for LED based street lights with scheduled ON time control by an Arduino board using solar power from solar cells and rechargeable battery.

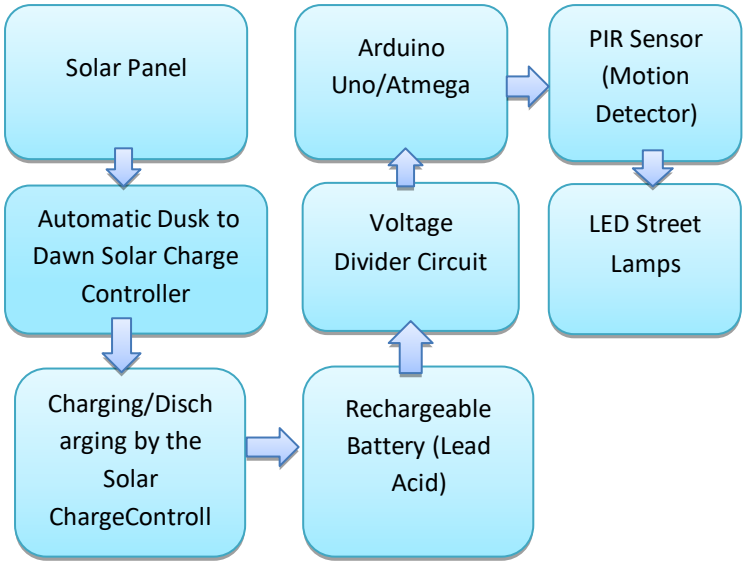


Fig 1: Block diagram

i. Solar Panel

Solar panel is one of the most important parts of solar street lights, as solar panel will convert solar energy into electricity. There are 2 types of solar panel: monocrystalline and polycrystalline. Conversion rate of monocrystalline solar panel is much higher than polycrystalline.

Type of lamp	Luminous efficiency	Lamp life (in hour)
High pressure sodium	50-150	15000-24000
Fluorescent	100-120	15000-20000
LED	70-160	4000-90000

Table1: Span Life of Different lamps

EQUATION FOR EFFICIENCY OF SOLAR PANEL
For e.g.: Suppose 250W panel ,1675mm long and 1001mm wide, efficiency is calculated using below equation
Its surface area is calculated as;
Surface area=l*b
=1675mm*1001mm
=1.675 sq.m
At STC watts per meter sq. (w/sq.m)=1000w/sq.m
Efficiency=245/(1.675*1000)=0.1462
%Efficiency=0.1462*100 =14.62%

ii. Arduino ATmega2560

The Arduino Mega is a microcontroller board based on the ATmega1280. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a adapter.

iii. PIR sensor:

An IR sensor is an infrared electronic device that emits in order to sense some aspects of the surroundings. An IR sensor can measure the heat of an object as well as detects the motion. These types of sensors measure only infrared radiation, rather than emitting it that is called as a passive IR sensor. A PIR sensor can also be called as a motion sensor.

iv. Lighting fixtures:

LED is usually used as lighting source of modern solar street light, as the LED will provide much higher Lumens with lower energy consumption. From Table.1 the energy consumption of LED fixture is at least 50% lower than HPS fixture which is widely used as lighting source in Traditional street lights. LED's lack of warm up time also allows for use of motion detectors for additional efficiency gains.

v. Rechargeable battery:

Referring Fig.1, Battery will store the electricity from solar panel during the day and provide energy to the fixture during night. The life cycle of the battery is very important to the lifetime of the light and the capacity of the battery will affect the backup days of the lights. There are usually 2 types of batteries: Gel Cell Deep Cycle Battery and Lead Acid Battery and many more.

Conclusion: Net metering is designed and implemented and tested successfully in DC mode of operation. Net metering arrangement for a consumer primarily offsets power consumption from the grid and therefore it compensates the owner of the rooftop system for solar energy consumption at the applicable rules and regulations and for retail tariffs for the category of consumers. As the power produced by solar energy using PV systems is difficult and costly to store, the net metering provides opportunity to supply the excess power produced to grid and when solar power is not sufficient or unavailable, power can be drawn from grid, thus creating an opportunity of two way supply and making solar energy more reliable. It provides the

simple, and easy-administered method for encouraging direct customer investment in small-scale renewable. This paper of net metering allows customer generators to offset a higher proportion of their retail electricity consumption with their own electricity generation.

The paper describes an automatic solar panel based LED street lighting system; it integrates latest technology such as LED technology and Renewable Energy Source in order to reduce power consumption, cost and manual controlling method.

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