Modeling of Energy Saving Circuit for House hold Appliances

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Abstract - **In the present day scenario due to the limited availability and depletion of conventional energy sources relying on non- conventional energy source is the best alternative for this problem .On the other hand better utilisation of non-conventional energy sources has to be made to bring down the power consumption cost .In this prototype a relevant solution is being made by automatic transfer switch and it can be implemented for household appliances. The automatic transfer switch is microcontroller based platform where the switching between utility service and solar PV system is made to power up the devices in such a way that cost of power consumption decreases. In this prototype Arduino platform based Atmega 328 p-pu microcontroller is used to control the switching operation .According to the voltages of utility and solar the switching action takes place. So in order to measure the voltages of utility service and solar powered batteries voltage divider circuits are being used and these analog values are given to microcontroller and upon comparison of these two values the switching i.e powering up of devices takes place in such a way that the electricity bill decreases as compared to conventional processes such as off-grid system. In this project the switching of devices is done using basic components in order to minimize the cost and one other hand meet the aim with accuracy.**

Index Terms - Hybrid grid system, off–grid system, arduino, priority loading.

I. Introduction

In the current scenario, electricity generation with a very advanced technology must emerge to meet the growing demand for global population growth. The conventional energy sources we depend on when they can be stored and the conversion is easy because of the pollution they cause, the extinction, the elimination of waste during their conversion and because many more with the deficit of the day they came to depend on renewable energy sources (RES) [1, 2]. In addition, with the generation of electricity, transmission and distribution plays an important role to meet consumer need. Nowadays, all commercial consumers can generate their own energy through the use of solar energy, which has become a trend. The expansion of the network in remote areas is technically laborious, which has led to the development of the distributed generation system based on RES [3]. Among the various renewable energy sources, wind and photovoltaic (PV) sources are gaining primacy in rural areas and electrification of remote areas around the world [4,5]. However, the generation of electricity from photovoltaic solar cells has been more recommended for domestic and domestic applications due to numerous advantages, such as the ubiquity of solar resource, modularity, silent operation, low maintenance costs and an appreciable level of reliability [5, 6]. These advantages of photovoltaic systems have led to the growth of their use all over the world. Germany is in first place in this regard (with a total distributed photovoltaic capacity of about 38.2 GW), followed closely by China and Japan with 28.2 and 23.3 GW respectively.

Despite the aforementioned advantages offered by photovoltaic solar energy in terms of meeting the electricity demand of remote residential buildings, there are still some challenges associated with the use of photovoltaic systems. The module performance prediction was studied using deterministic models and probabilistic approaches [7, 8]. Furthermore, the development of optimal sizing methodologies for systems for photovoltaic systems based on statistical methods [9] and artificial intelligence [10, 11] was studied. Although many techniques and schemes for monitoring the maximum power point (MPPT) are provided in the literature, which is the generational part, the management of the demand side is not concentrated. Therefore, the management of the demand side is made in this document.

When the energy generated by the solar power plant exceeds our demand, there is a provision to export this excess of energy in the network. In return, the government will pay us based on the amount of energy we have exported. This is known as a network measurement system and the network involved in this process is known as an online network system [12]. The Off Grid system does not imply network connectivity and power, making it an isolated generation [13]. The Hybrid Grid System uses both grid energy and solar energy to meet load demand [14]. This priority load manages the shared load between the electricity grid and the generated solar energy, which shows a decrease in the electricity bill. Different methods of price differentiation are currently used. They are Time- Of - Use (TOU) prices, Day-Ahead Pricing (DAP) and real-time prices (RTP) described in [15] - [19].

In this project we are using Arduino for controlling and for displaying the state of charge of battery Liquid Crystal Display. Solar energy is used for charging the batteries. According to the demand and priority of loads the load is shared between solar and utility supply.

II. Solar Power Plants

A. ON-Grid System

Solar systems connected to the grid or on-grid is by far the most common and widely used by households and businesses. This system is connected to the public power grid and do not require battery conservation. Any solar energy generated by a system in the network (which is not used directly in your home) is exported to the electricity grid and, in general, you are paid a commission for the energy you export [20].

Unlike hybrid systems, solar systems connected to the network cannot operate or generate electricity during a power outage or blackout for safety reasons; since blackouts usually occur when the power grid is damaged.

If the solar inverter continues to supply electricity to a damaged network, the safety of people repairing faults in the network would be compromised. However, most battery-powered hybrid solar systems are able to isolate themselves automatically from the network (what is known as "island") and continue to operate during a power outage.

B. *OFF-Grid System*

An off-grid system isn't connected to the electricity grid and so needs battery storage. An off-grid solar scheme should be designed fittingly in order that it'll generate enough power throughout the year and have enough battery capability to satisfy the home's needs, even in the extreme winter when there is less sunlight. The high value of batteries and inverters means off-grid systems are rather more pricy than on-grid systems and so are solely required in more remote areas that are far from any electricity grid. However battery costs are reducing rapidly, so there is currently a growing marketplace for off-grid solar battery systems even in cities and towns.

C. *Hybrid Grid System*

Modern hybrid systems combine solar system and battery storage. This means having the ability to store solar power that's generated throughout the day and utilizing it at midnight. When the hold on energy is depleted, the grid is there as a backup. Hybrid systems are also able to charge the batteries using cheap off-peak electricity (usually after midnight to 6am).

III. State Of Charge Of Battery

The state of charge, SOC(t), of a battery at any time t is the amount of battery charge (Q_R) at the pre-established time. It is limited by SOC_{min} and SOC_{max}, where SOC_{min} is the minimum amount of the battery charge while SOC_{max} is maximum amount of the battery charge. With the maximum charge, SOC(t) $=SOC_{max}=Q_R$ The solar irradiation which is the resource of the PV system is highly intermittent in nature and could produce excess or deficit energy[21]. This deficit/excess energy which represents the power delivered/absorbed by the battery is given by

$$P_B(t) = P_{pv}(t) - \frac{P_{dem}(t)}{\eta_{inv}} \qquad (1)$$

Where $P_{PV}(t)$ and $P_{dem}(t)$ are the total power produced by the photovoltaic plant and the total demand for energy from loads at time t; and η_{inv} is the efficiency of the inverter.

When $P_B(t)$ >0, it indicates there is an excess solar power generation by the PV system but when $P_B(t)$ < 0, then there is deficit of solar power generation. Charging of the battery storage only occurs when there is an excess of electrical power from the PV and the state-of-charge of the battery is below than the maximum (SOC(t) < SOCmax). During charging, the state of charge of the battery storage at time t, SOC(t) is given by (2)

$$SOC(t) = SOC(t-1).(1-\sigma) + \left(P_{pv}(t) - \frac{P_{dem}(t)}{\eta_{inv}} \right).\eta_B \qquad (2)$$

When there is a deficit in solar power generation and the battery storage is above its minimum state of charge (i.e. $P_B(t)$ < 0 and SOC(t) > SOCmin) the battery storage is discharged to provide the deficit according to

$$SOC(t) = SOC(t-1).(1-\sigma) + \left(\frac{P_L(t)}{\eta_{inv}} - P_{PV}(t) \right).\eta_B \qquad (3)$$

And Eq. (3) can be written as

$$SOC(t) = SOC(t-1).(1-\sigma) - P_B(t)\eta_B \qquad (4)$$

Where η_{inv} , η_B and σ are the inverter efficiency, battery storage efficiency and hourly self-discharge rate respectively.

IV. Arduino [22]

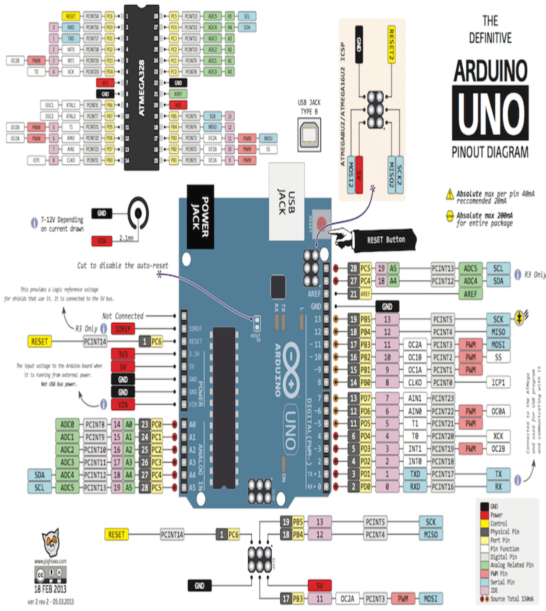

Fig. 1 Arduino UNO description.

A. *Features of ATMEGA 328 P-PU*

- High Performance microcontroller , 8 –Bit AVR low power consumption
- Advanced RISC Architecture
- High Endurance Non-volatile Memory Segments
  - 32K Bytes of flash memory automatically programmable in the system (ATmega328)
  - lK Bytes EEPROM (ATmega328) -2K Bytes Internal SRAM (ATMEGA328)
  - Write/Erase Cycles: 10,000 F1ash/100,000
- Peripheral Features
  - Two 8-bit Timer/Counters with separate prescaler and comparison mode.
  - A 16-bit Timer/Counter with separate prescaler, comparison mode and acquisition mode.
  - Six PWM Channels
  - 10-bit ADC with 6 channels in the PDIP package
  - Temperature measurement
  - USART serial programming
  - SPI programmable monitoring timer/SPI slave with separate on -chip oscillator.
  - On-chip Analog Comparator
  - Real Time Counter with separate oscillator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Six Sleep Modes: Idle, ADC Noise reduction, power – down, power- save standby, and extended standby.
- I/O and Packages
  - 23Progmmable I/O lines
  - 28-pin PDIP, 32-lead TQFP, 28-pad QFN/MLF and 32-pad

QFN/MLF

Operating Voltage

- 1.8 to 5.5V for ATmega328

- Temperature Range
  - -40°C to 85°C
- Speed Grade:
  - 4 MHz@1.8 - 5.5V, 0 - 10 MHz@2.7 - 5.5.V, 0 - 20 MHz @ 4.5 to 5.5V

B. Pin Configuration

Port B is having an 8-bit bidirectional I / O port pins with internal pull-up resistors. The port B output buffers have symmetrical characteristics of the unit with high absorption capacity and source As input, the externally extracted port B pins will lower the current if the pull-up resistors are activated. The pins of Port B are set to tri-stated when a reset condition is activated, even if the clock does not work. The PB6 can be used as input for the inverter oscillator amplifier; PB7 can be used as output for the inverter oscillating amplifier using the clock selection fuse setting and can also be used as the input to the clock's internal operating circuit. By using internal calibrated RC oscillator as the clock source of the chip, PB7 ... 6 is used as input TOSC2 ... 1 for the asynchronous timer / counter2 if the AS2 bit is set to ASSR.

Port C is having 7-bit bi-directional I/O port pins with internal pull-up resistors. The output buffers of PC5.0 have high sink and source capability symmetrical drive characteristics. As inputs, Port C pins that are externally pulled decrease source current if the pull-up resistors are activated. When a reset condition becomes active, Port C pins are tri stated even if the clock is not running

PC6 is used as an I/O pin by programming the RSTDISBL Fuse. The electrical characteristics of PC6 and other pins in Port C are different. PC6 is used as a reset input If the RSTDISBL fuse is not programmed. A low level on this pin for longer than the minimum pulse duration will result in a reset, even if the clock does not work.

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The output buffers of port D have symmetrical drive characteristics with high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not ON.

AV_{CC} is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It must be externally connected to V_{CC}, even if the ADC is not used. If the ADC is used, it should be connected to V_{CC} via a low-pass filter. Note that PC6...4 use digital supply voltage, V_{CC}

AREF is the analog reference pin for the A/D Converter.

In the TQFP and QFN/MLF package, ADC: 6 acts as an analog input to the A/D converter. These pins are powered from the analog supply and act as a 10-bit ADC Channel.

V. PROGRAM CODE

```
#include <SoftwareSerial.h>
#include<LiquidCrystal.h>
LiquidCrystal lcd(12,11,5,4,3,2);
unsigned char j=0;
int x1,power;
const int r1=6;
const int r2=7;
const int r3=8;
const int r4=9;
const int s1=10;
const int led=13;
unsigned char x=0;

void setup() {
pinMode(r1,OUTPUT);
pinMode(r2,OUTPUT);
pinMode(r3,OUTPUT);
pinMode(r4,OUTPUT);
pinMode(led,OUTPUT);
pinMode(s1,INPUT);

digitalWrite(r1,0);
digitalWrite(r2,0);
digitalWrite(r3,0);
digitalWrite(r4,0);
digitalWrite(s1,1);

lcd.begin(16,2);
delay(2000);
lcd.clear();
lcd.setCursor(0,0);
lcd.print("PRIORITY BASED  ");
lcd.setCursor(0,1);
lcd.print("LOAD MANAGEMENT ");
delay(5000);

lcd.clear();
lcd.setCursor(0,0);
lcd.print("BAT.CHARGE:     %");
lcd.setCursor(0,1);
lcd.print("                ");
delay(5000);
}

void loop() {
for(x=0;x<3;x++)
{

int x=analogRead(0);
x1=map(x,0,1023,0,100);
delay(300);
lcd.setCursor(13,0);
lcd.print("    ");
lcd.setCursor(13,0);
lcd.print(x1);
delay(100);
power=digitalRead(s1);
}

if((x1>75)&(power==1))
{
digitalWrite(led,1);
digitalWrite(r1,1);
digitalWrite(r2,0);
digitalWrite(r3,1);
digitalWrite(r4,1);
}
if((x1<75)&(x1>50)&(power==1))
{
digitalWrite(led,1);
digitalWrite(r1,1);
digitalWrite(r2,1);
digitalWrite(r3,0);
digitalWrite(r3,1);
digitalWrite(r4,1);
```

```
}
if((x1<50)&(power==1))
{
digitalWrite(led,1);
digitalWrite(r1,0);
digitalWrite(r2,1);
digitalWrite(r3,1);
digitalWrite(r4,1);
}
if((x1>75)&(power==0))
{
digitalWrite(led,0);
digitalWrite(r1,1);
digitalWrite(r2,0);
digitalWrite(r3,1);
digitalWrite(r4,1);
delay(1000);
}

if((x1<20)&(power==0))
{
digitalWrite(led,0);
digitalWrite(r1,0);
digitalWrite(r2,0);
digitalWrite(r3,0);
digitalWrite(r4,0);
}
}
```

TABLE I
SWITCHING LOGIC

S.NO	Utility Service	Solar Battery Voltage level	Loads on utility	Loads on solar battery
1	Available	>75	0	2
2	Available	50<V<75	1	1
3	Available	<50	2	0
4	Zero	>50	0	2
5	Zero	20<V<50	0	1

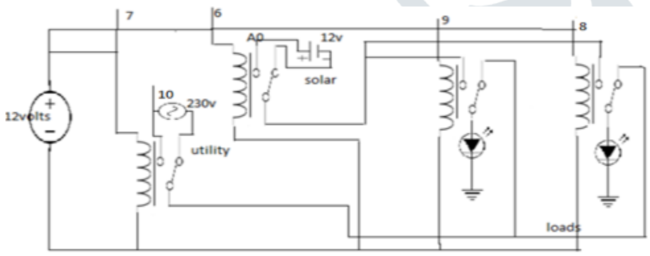

Fig:2 Control Circuit diagram

VI. RESULTS

An ARDUINO-based smart energy saving switching circuit model is developed to reduce the electricity bill. A Potential divider (1kohm and 100ohms) and four relays (SRD -05VDC) are used for sensing the solar and electricity board supply voltage levels according to arduino control algorithm. A program is developed for the control of priority loading.

When utility is present and solar charged battery SOC greater than 75% all the loads burden will be on solar charged battery. On the other hand when utility is available and solar charged battery SOC range lies between 50% to 75% half of the loads are on utility service and other half on solar charge battery. And during power cut burden on solar charged battery is according to its SOC.

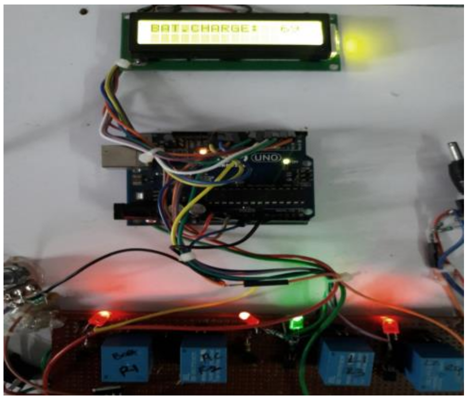

Fig:3 Utility supply ON and battery charge 69%

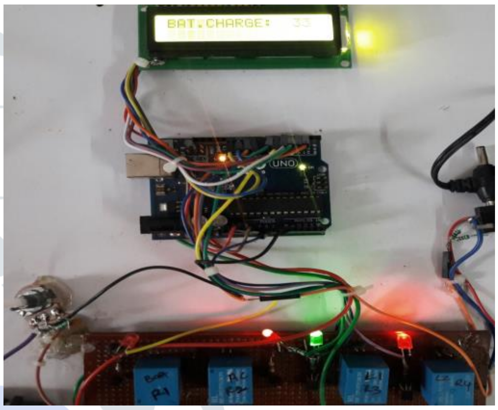

Fig:4 Utility supply ON and battery charge 33%

VII. CONCLUSION

By implementing above type of methodology we will get reductions in our electricity bill. In grid tied system there is a possibility of sold back the excess electric power generated from the solar. Conventional energy resources like fuels are decaying day by day. After Hundreds of years there may be no fuels from the earth mostly. So we have to depend mostly on solar and other renewable energy resources. So we have to put more concern about importance and utilization of solar energy and other renewable energy resources. Solar energy is free from pollution and does not cause the emission of greenhouse gases after installation.

Demand side management (DSM) or load management is a vital method of leveling the availability of electricity on the network with the electrical load by adjusting the load rather than the power station output. Load management allows utilities to reduce costs by eliminating need for peaking power plants. Load management can also help to reduce harmful emissions where backup generators cause pollution to environment and less efficient.

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