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Renewable Energy Management Using Peripheral Interface Controller Based Power Meter.

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ABSTRACT

The paper is aimed at designing a management system that monitors renewable energy battery charging system. It incorporates a locally designed Power meter using microcontroller programmed using C language and a liquid crystal display. The microcontroller uses the processing speed of a computer to initiate and execute instructions. The microcontroller is connected to the wind and solar renewable system through the ACS 712, a current sensor that measures current and voltage divider network for the voltage measurement. The analogue current and voltage readings are processed by the PIC18F452microcontroller displaying the voltage, current and power readings. The load currents connected to the input port of the Peripheral Interface Controller are fed to the battery banks to charge the batteries. The switching arrangement of relays or contractors is connected through transistors to the output port of the microcontroller. This initiates switching from one battery bank to another. This it does by measuring the load current of the two renewable energies supply and switches the larger battery banks to be charged with the higher generated load current and smaller battery bank with lower load current. This ensures the power level of the battery bank is kept fairly constant during usage. This study shows the use of a locally designed PIC based power meter using two sources of renewable energy. This is not possible using the solar charge controller which is another form of a renewable management system and only accommodate solar energy. It also has no switching system which is an important feature of the locally designed PIC based Power meter. This study also shows that the PIC base power metering is cost-effective as it can manage different renewable energy sources compared to other renewable energy management system which can manage only one kind of renewable energy source.

Keywords: renewable energy, peripheral interface controller, voltage levels, energy demand, switching.

INTRODUCTION

Renewable energy provides fluctuating power due to natural factors and makes power planning difficult. It, therefore, becomes imperative to ensure the efficiency and stability of electricity Supplied.

Due to environmental and natural conditions, solar radiation is not constant throughout the day, so also the wind speed varies continuously, therefore energy generated from solar, wind and hydro fluctuate continuously and as such effective management of this energy must be carefully planned out. The method of management used in this paper involves connecting to different energy based on demand. Energy cannot be stored as A.C and can only be stored as D.C, the power level of this energy will also be a tool in determining to switch of energy from one source of energy to another; in this case from solar to wind and vice versa. The voltage at the output of the inverter is stable. The only fluctuating voltage here is the voltage generated at the source i.e voltage from solar cells and from the wind turbine.

The amount of current drawn depend on the load connected. ACS 712 is the hall effect sensor used to determine the current drawn while the use of the resistor as a voltage divider determines the voltage generated in the power meter circuitry. The design utilizes a relay switching system to achieve its switching goal. The management of renewable energies has been gaining interest in recent years as the world push forward to replace the brown energy with green energy.

During recent decades, both domestic and global consumption of energy is growing rapidly. According to 2010 report of the International Energy Agency, in the United States, total consumption of energy in the USA from 1990 to 2008 increases by 20% while the global demand for the same period increased by 39%. The global demand for energy is rising more rapidly than previously thoughts (International Energy Agency, 2010). Consumption of electricity increases year to year as more home appliances are installed. So, efficient use of energy becomes a top priority.

Non-renewable energy brings about environmental degradation arising from pollution caused by the emission of CO_2 into the atmosphere. Renewable energy is generated from natural resources such as sunlight, wind, rain, tides and geothermal heat, which are naturally replenished compared with a conventional energy source (Cheng, 2012). Renewable energy which is naturally replenishing takes a central place compared to fossil fuels which are limited (Nupur et al. 2015). Intelligent approaches have been used for forecasting of load, price and other parameters to develop efficient Energy Management Systems. Load forecasting helps in proper planning and efficient allocation of resources (Lara, 2007).

In this paper, an economical method of renewable energy management is developed using PIC based Power metering with automatic switching. The abundant sunshine in the Northern part of Nigeria and in general the entire nation can be harnessed to produce solar energy for use in our homes. Solar energy produced from solar cells has to be converted to A.C using inverting circuit and boosting up with a transformer. According to (Ajayi et al. 2014) wind energy is suitable parts of southwestern Nigeria were an average wind speed of 2.9m/s to 5.8m/s was recorded. Wind power generation has not been developed effectively in producing several megawatts of energy using wind turbine and making use of the vast landmass of the Northern part of Nigeria to create wind farms (Ojosu, 1989). Electricity is generated from a wind turbine which converts the kinetic energy in the wind into electrical power. Jasper et al. (2017) evaluated the wind potential in Nigeria at different locations onshore and offshore and concluded that wind power increases as one move from onshore to offshore.

MATERIAL AND METHOD

The following are the methods and procedures that would be adopted:

1 Design of a microcontroller based Power metering and automatic switching.
2 Programming code for the microcontroller based Power meter.
3 Wind speed and Energy extracted by a Wind Turbine in Abeokuta Metropolis

Design of a microcontroller based Power metering and automatic switching

Current sensor ACS712 is used to determine the current of the solar panel and the wind turbine and the voltage is obtained through the arrangement of resistors using them as a voltage divider. The Micro-controller process these values.

Ac voltage measurement using picmicrocontroller

Resistor R1 and R2 are used as a voltage divider to the ADC input of the micro-controller which is pin 4

Vdc =13v

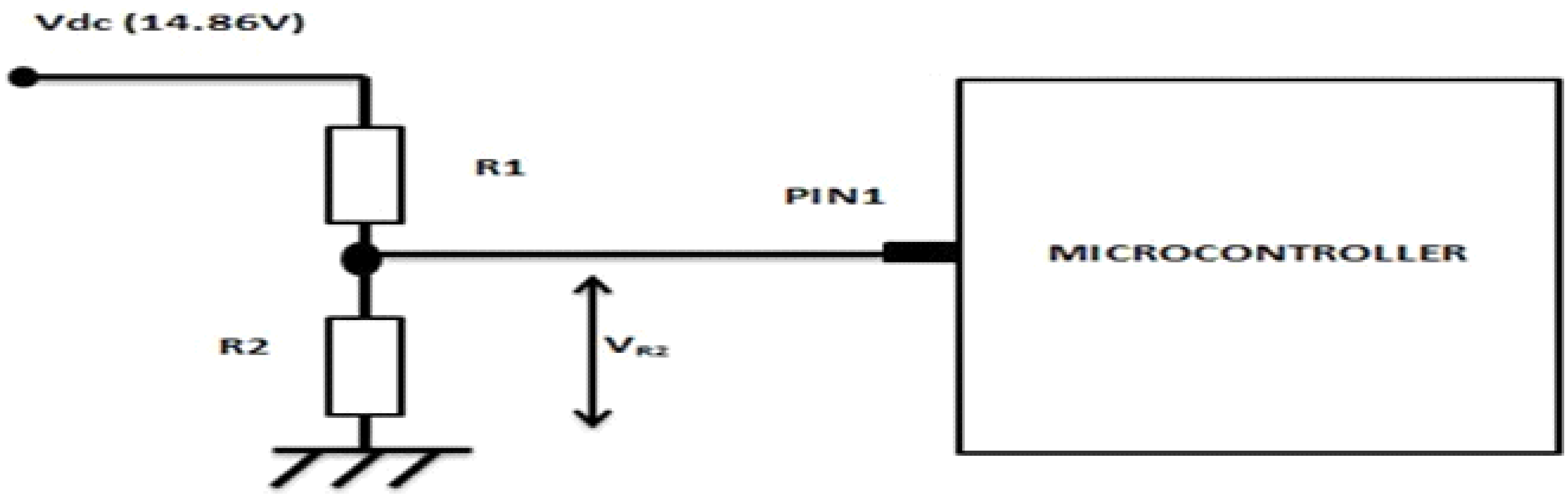

Fig1: showing Micro-controller connection to a resistors acting as voltage divider

Wind Turbine Voltage

Total resistance = R1 + R2 = R_0

Voltage across R2 = $\frac{R2}{R1 \quad R2}$ Vdc

adc_volt = $\frac{\text{adc result x } 0.00488}{0.0144v}$ (1)

Solar Panel Voltage

Total resistance = R1 + R2 = R_0

Voltage across R2 = [$\frac{R2}{R1 \quad R2}$] Vdc

adc_volt = $\frac{\text{adc result x } 0.00488}{0.0144v}$ (2)

Current Measurement

SOLAR CURRENT

At 66mV input the current sensor gives 1A

On no-load, the ACS712 gives 2.5 volts and for every 66mV input, the output is 1A

Solar current

The LCD prints the value contained in current to the LCD screen.

Wind Turbine Current

At 66mV input the current sensor gives 1A

On no-load, the ACS712 gives 2.5 volts and for every 66mV input, the output is 1A

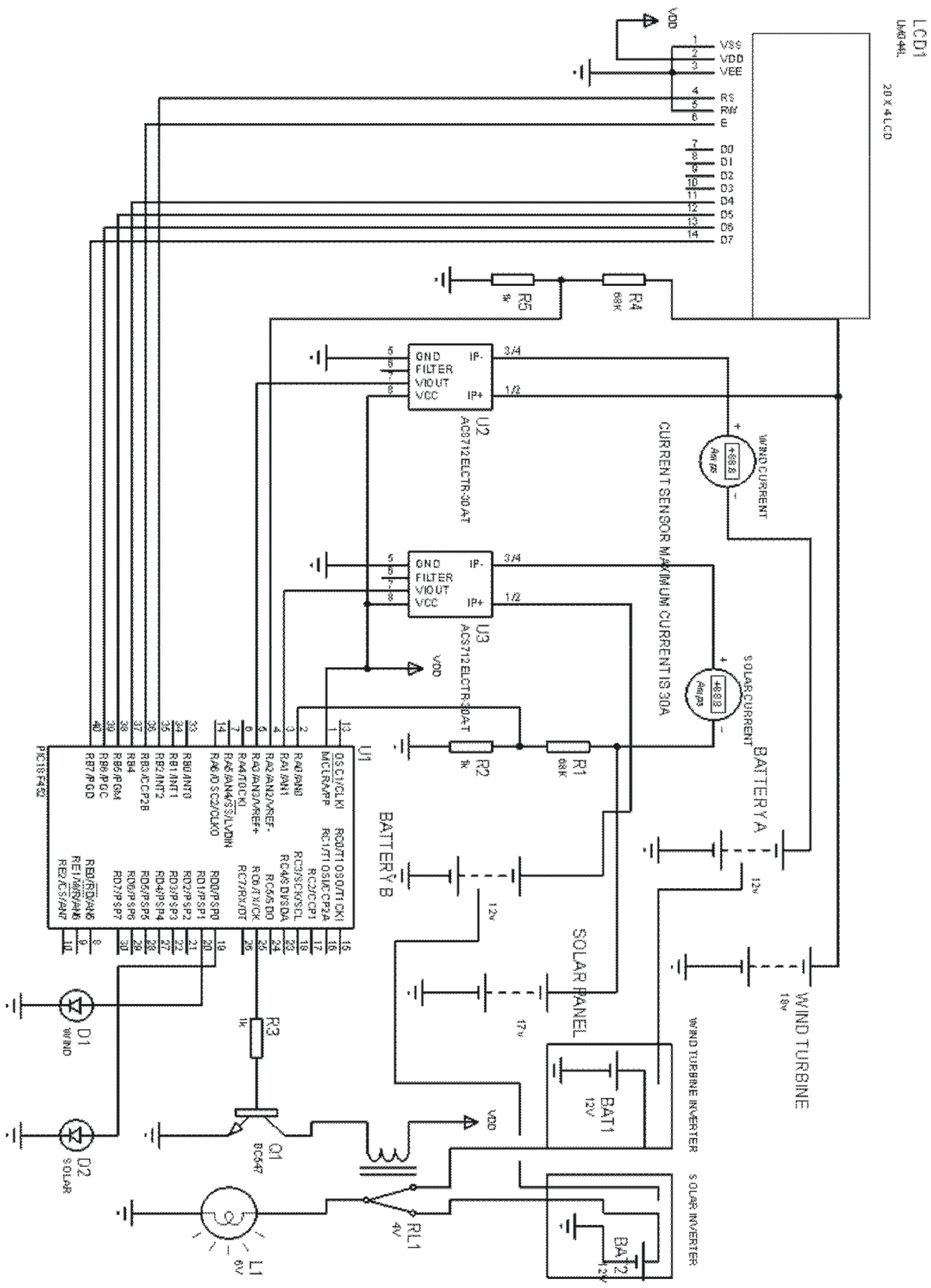

Fig 2: Circuit diagram showing Micro-Controller based metering and automatic switching

CODE FOR THE POWER METERING

```
//LCD CONFIGURATION CODE
sbit LCD_RS at RB2_bit;
sbit LCD_EN at RB3_bit;
sbit LCD_D4 at RB4_bit;
sbit LCD_D5 at RB5_bit;
sbit LCD_D6 at RB6_bit;
sbit LCD_D7 at RB7_bit;

sbit LCD_RS_Direction at TRISB2_bit;
sbit LCD_EN_Direction at TRISB3_bit;
sbit LCD_D4_Direction at TRISB4_bit;
sbit LCD_D5_Direction at TRISB5_bit;
sbit LCD_D6_Direction at TRISB6_bit;
sbit LCD_D7_Direction at TRISB7_bit;
// End LCD module connections

//THE FORMAT OF DISPLAY VALUE IN
DECIMAL FORM
 sbit relay at RC6_bit ;

float solar_volt=0;
float solar_current=0;
float solar_power=0;


float wind_volt=0;
float wind_current=0;
float wind_power=0;
float volt;

char wind_txt[7];
char solar_txt[7];
char windv_txt[7];
char solarv_txt[7];


long  adc_res;
int i;
// CONFIGURATION OF THE
MICROCONTROLLER
void main() {
  PORTA=0;
  PORTB=0;
  PORTC=0;

  TRISA=0B11111111;
  TRISB=0;
  TRISC=0;
  ADCON1=0B00000000;
  Lcd_Init();                    // Initialize LCD
  Lcd_Cmd(_LCD_CLEAR);       // Clear display
  Lcd_Cmd(_LCD_CURSOR_OFF); // Cursor
off
  Lcd_Cmd(_LCD_CLEAR);

  lcd_out(1,1,"RENEWABLE ENERGY") ;
  lcd_out(2,1,"MANAGEMENT SYST") ;
  DELAY_MS(1000);
  Lcd_Cmd(_LCD_CLEAR);

       lcd_out(1,1,"SOLAR    |  WIND");
       lcd_out(2,1,"         |        ");
       lcd_out(3,1,"         |        ");
       lcd_out(4,1,"         |        ");


while(1)
  {    adc_res =0;
///////////////SOLAR VOLTAGE READINGS
PROGRAMMING  CODE//////////////////
for(i=0;i<32;i++)
      { adc_res +=adc_read(0);      }
       adc_res=    adc_res/i;
       solar_volt= adc_res * 0.3372;


//////////WIND VOLTAGE READINGS
PROGRAMMING CODE/////////////
      adc_res =0;
for(i=0;i<32;i++)
      { adc_res +=adc_read(2);    }
       adc_res=    adc_res/i;
       wind_volt= adc_res * 0.3372;
```

```
///////////SOLAR CURRENT READINGS
PROGRAMMING CODE ////////
     adc_res =0;
for(i=0;i<32;i++)
      { adc_res +=adc_read(1);    }
      adc_res=    adc_res/i;
      volt= adc_res *4.99/1023;
      solar_current=(volt-2.5)/0.066;
      solar_current=fabs(solar_current);

//////////WIND CURRENT
READINGSPROGRAMMING CODE ///////////
     adc_res =0;
for(i=0;i<32;i++)
      {  adc_res +=adc_read(3);   }
      adc_res=    adc_res/i;
      volt= adc_res *4.99/1023;
      wind_current=(volt-2.5)/0.066;
      wind_current=fabs( wind_current);

/////////SOLAR
POWERREADINGSPROGRAMMING
CODE ///////////////////
      solar_power=  solar_current * solar_volt;

/////////WIND POWER///////////////////
      wind_power=  wind_current * wind_volt;

//////////////COMPARISON////////////
if (solar_power > wind_current )relay=1;
else
      { relay=0;    }

//////////////////DISPLAY PARAMETERS ON
20X4 LCD/////////////////////

      floattostr (solar_volt,solarv_txt);
solarv_txt[4]=0;
      lcd_out(2,1,solarv_txt);lcd_chr_cp('V');
      floattostr (wind_volt,windv_txt);
windv_txt[4]=0;
      lcd_out(2,13,windv_txt); lcd_chr_cp('V');

      sprintf (solar_txt,"%f",solar_CURRENT);
solar_txt[4]=0;
      lcd_out(3,1,solar_txt);  lcd_chr_cp('A');

      sprintf (wind_txt,"%f",wind_CURRENT);
wind_txt[4]=0;
      lcd_out(3,13,wind_txt); lcd_chr_cp('A');

      floattostr (solar_power,solar_txt);
solar_txt[6]=0;
   lcd_out(4,1,solar_txt);
      lcd_chr_cp('W');
      floattostr (wind_power,wind_txt);
wind_txt[6]=0;
      lcd_out(4,13,wind_txt);
      lcd_chr_cp('W');
```

Solar Panel Voltage(v)	Load current for Appliances using Solar (A)	Wind Turbine Voltage (v)	Load current for Appliances using Wind Turbine (A)
12.4	5.06	13.1	9.86

The Table 1 above shows the readings from the design power meter. If the power produced by the wind turbine is higher than that produced by solar cells for a predetermined time, the wind turbine is switched to the highest load and the solar cells are switched to the smaller load based on capacity. The power meter does a monitoring job by ensuring the right renewable energy is connected. The power meter connects the one with the higher load (9.86A) to more battery bank and connects the one with a lesser load(5.06A) to a reduced number of the battery bank.

Table 2: Solar Panel Voltage and Power

Time	Irradiance (W/m^2)	Temperature (⁰C)	Humidity (g/m^3)	Solar Panel 1 Voltage(V)	Solar Panel 1 Current(A)	Solar panel 1 Power (watt)	Solar Panel 2 Voltage	Solar panel 2 Current (A)	Solar Panel 2 Power (Watt)
8:00 am	18	23	91	33.3	0.11	3.66	31.3	0.11	3.44
8:30 am	36	23.5	96	36.4	0.23	8.37	35.4	0.24	8.49
9:00 am	65	24	92	39.6	0.57	22.52	39.5	0.62	24.49
9:30 am	150.4	25	92	40.9	1.07	43.76	40.8	1.09	44.47
10:00am	191.1	25	92	41.3	1.53	63.19	41.4	1.67	69.14
10:30 am	237.8	26.5	88	42	2.82	118.44	41.7	2.8	116.76
11:00am	158	25	92	39.1	0.82	32.06	39.1	0.78	30.5
11:30 am	344	26	84	42.3	3.6	152.28	42.6	3.84	163.58
12:00pm	325	26	92	41.3	2.28	94.16	41.2	2.13	87.76
12:30 pm	456	30	85	41.2	3.35	138.02	41.6	3.15	131.04
01:00pm	1355	40	82	41.8	9.04	377.87	42.3	8.26	349.4
01:30 pm	494	29	92	41.2	3.66	150.79	41.5	3.56	147.74
2:00pm	1011	35	87	42.9	8.6	368.94	42.3	8.41	355.74
2:30 pm	312	28	92	41	1.89	77.49	40.4	1.77	71.51
3:00pm	277	27.5	88	41.7	2.02	84.23	41.6	2.18	90.69
3:30 pm	184.4	26	92	41.8	2.25	94.05	41.9	1.82	76.26
4:00pm	191.6	27	92	41	2.37	97.17	41.5	1.82	75.53

The above table2 shows the practical readings obtained from a wind turbine and photovoltaic cells. The power produced at any point in time from the two renewable sources can charge the battery banks comfortably. Solar voltage and current readings show that photovoltaic cell is very effective from 110am to 4 pm. Also, substantial wind speed can also be obtained during the period. At night, wind energy becomes more reliable and solar cells become ineffective. Wind energy can supply the energy needs during the night. It is also observed that the Wind Turbine can create substantial Energy when the wind speed is higher. For this reason, the height of the turbine can be made much higher.

CONCLUSION

PIC-based power metering management is a cost-effective method of managing renewable energy compared to other forms of renewable energy management systems. Another form of energy management tool like the solar charge controller manages one kind of renewable energy(solar) loads. The PIC-based Power meter is designed to manage more than one source of renewable energy- solar cells and wind turbine system. It is also more efficient as it incorporates power consumed as a key management tool.

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