Research Article

Design of calculator for performance assessment of photovoltaic solar cell

Abstract

Photovoltaic solar system encompasses promising role to mitigate threat of energy reserves depletion. This paper assesses the performance of microcontroller and PCW based calculator permitting efficiency check of system. It investigates temperature impact on parameters defining photovoltaic solar panel performance viz open circuit voltage, short circuit current, fill factor and efficiency. Calculator results recorded using HyperTerminal 7.0 proved theoretical facts of solar power parameters associated with temperature influence.

Keywords: solar cell, microcontroller, performance, efficiency, electrical parameters

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Introduction

Sun energy is regarded as fuel to life. All forms of energy on earth take origin directly or indirectly from sun.[1] Solar energy maintained effective contribution in fossil fuels coal, oil, and natural gas formation.[2] Yet with rapid utilization of conventional energy resources and long formation period[1] fossil fuels reflect hands off to everlasting energy demand. 75% of world energy supply consumed by wealthy industry economy forming 25% of world population.[3] Burning fossil fuels contribute environmental pollution; greenhouse gas emission, acid precipitation, enhanced global temperature and many more. A shift is made to renewable sources from non-renewable sources to tackle pronounced problems associated with conventional resources. Wind, solar, hydrogen, biomass, geothermal energy all count non-renewable energy sources. However, solar energy copes best to meet pollution free endless energy demand[4] worked for efficient battery charging using C programming.[4] Ike C.U. investigated performance of photovoltaic modules concluding high efficiency maintained with high air currents flow keeping low module temperature[5,6] analysed small change in current accompanying high voltage change for high temperature range.[6]

Installing PV solar system fully equipped with system components at a site appear expensive yet. Therefore pre-installation study becomes mandatory with efficiency constraints known. The proposed system counts inexpensive exposure to check effectiveness of ongoing PV solar system for a particular site before actual system installation.

Solar cell

Semiconductor materials are used in module fabrication. Solar cell develops PN junction forming positive and negative regions. Photocurrent generations principle Figure 1 governs working of cell. Photons absorbed by semiconductor trigger electrons move positive region through external circuit. This movement causes current generation.[7] Single solar cell appears impractical for solar applications. Many cells connected in series develop module produces valuable voltage. Modules in series or parallel combination develop panels/arrays for high voltage/current applications. Figure 2 shows equivalent circuit and array formation of solar cell.[8]

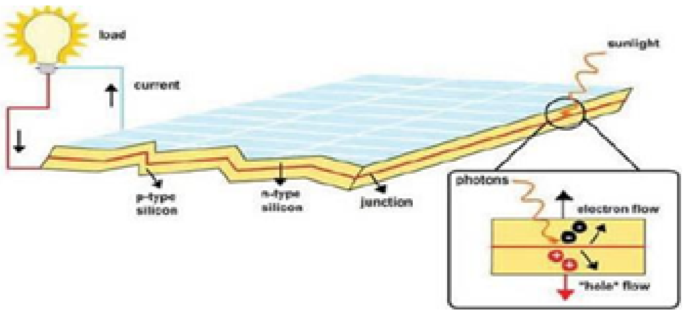

Figure 1 Photocurrent generation.

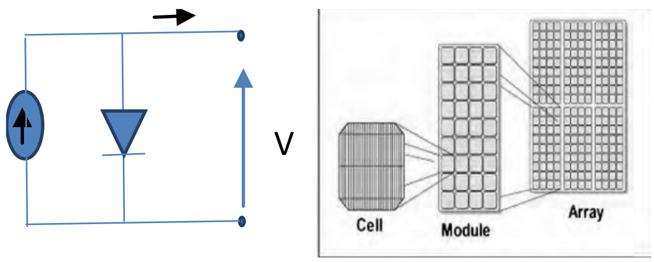

Figure 2 Equivalent circuit model (left). PV Cell to Array Formation (right).

Proposed setup

Figure 3 shows setup developed to investigate performance of PV solar panel. Control Panel powered through AC power supply steps down to 5V AC inverted to 5V DC where microcontroller operates. Non-inverting op-amp by varying gain property and voltage divider circuit designed measure current and voltage variations according to load and temperature variations. Surface temperature of panel recorded by thermocouple wire embedded in control panel with temperature measuring circuitry. Recorded data fed to PC interfaced to MAX 232 serial port interface circuit by RS 232 serial-USB converter. PCW C Compiler writes data on microcontroller and Hyper Terminal 7.0 reads and captures it out using built in capture function configured as detailed in Table 1.

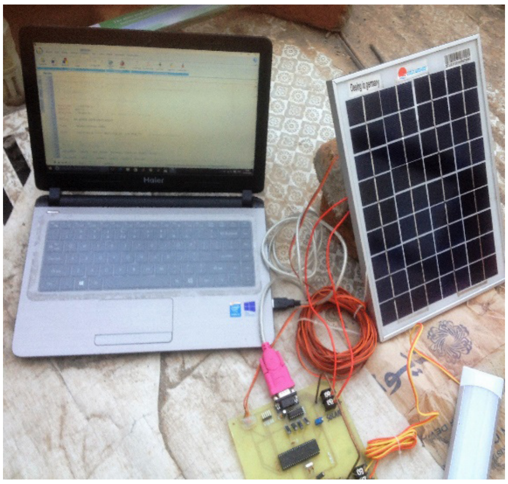

Figure 3 Experimental Setup.

Table 1 Hyper Terminal Configuration

Parameters	Configuration
Baud Rate	9600
Parity	None
Flow Control	None
Data Bits	8

Im and Vm obtained from recorded currents and voltages give Pm. The other parameters calculated using following equations to assess performance of PV solar module.

$$Pm = Vm * Im \tag{1}$$

$$FF = \frac{Vm*Im}{Voc*Isc} \tag{2}$$

$$\eta p = \frac{Pmea}{Pm(STC)}*100 \tag{3}$$

$$\eta m = \frac{Pmea}{S*A}*100 \tag{4}$$

Above equations calculate maximum power, fill factor, normalized output power efficiency and module efficiency respectively.

Materials

i. PC
ii. PV Panel
iii. DC Load
iv. Control Panel
v. Microcontroller 16f877a
vi. Voltage Divider Circuitry
vii. AC-DC Conversion Circuitry
viii. Serial Port Interface MAX 232
ix. Temperature Sensing Circuitry
x. Serial-USB Converter RS-232 (Figure 4)

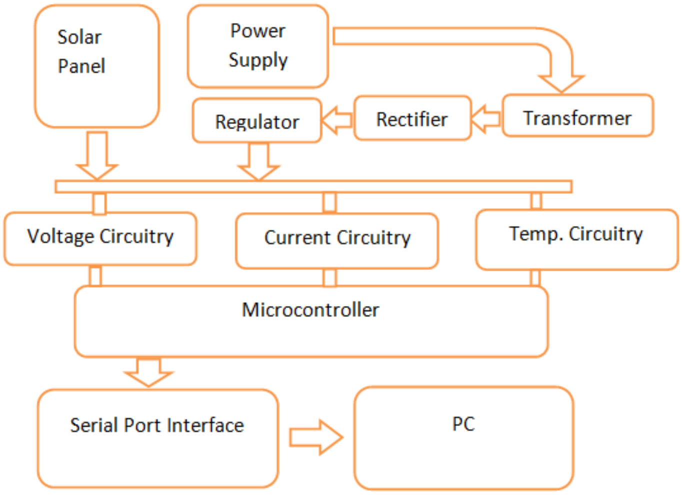

Figure 4 System Block Diagram.

Programming

```
#include <16f877a.h>
#device adc=10
#include <stdio.h>
#fuses HS,NOWDT,NOPROTECT,NOLVP
#use delay(crystal=4MHz)
#use rs232(baud=9600, xmit=PIN_C6, rcv=PIN_C7)
void adc_read (void);
void bcd (void);
void main()
{ setup_adc_ports(all_analog);
setup_adc(adc_clock_div_64);
while(1)
{
delay_ms(2000);
delay_ms(2000);
count++;
if(count > 9999) count=0;
adc_value=count;
bcd();
printf("\r\n\nSr No.");
putc(digit4+0x30);
putc(digit3+0x30);
```

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```
putc(digit2+0x30);
putc(digit1+0x30);
putc(' ');
void adc_read (void)
{
unsigned int32 adc_sample=0;
unsigned int8 count;
for(count=0; count < 50; count++)
{
adc_sample = adc_sample + read_adc();
delay_ms(5);
}
adc_sample = adc_sample / 50;
adc_value = adc_sample * 500 / 1023;
}
void bcd (void)
{ unsigned int16 temp;
temp = adc_value;
digit1 = temp%10;
temp = temp/10;
digit2 = temp%10;
temp = temp/10;
digit3 = temp%10;
temp = temp/10;
digit4 = temp%10;
} 1
```

Results and discussion

Sr No.0120 Voltage=10.0V Current=0.4A Power=004W Temperature=39C

Sr No.0121 Voltage=10.0V Current=0.5A Power=005W Temperature=41C

Sr No.0122 Voltage=10.0V Current=0.5A Power=005W Temperature=43C

Sr No.0123 Voltage=10.0V Current=0.5A Power=005W Temperature=42C

Sr No.0124 Voltage=10.0V Current=0.5A Power=005W Temperature=42C

Sr No.0125 Voltage=10.0V Current=0.5A Power=005W Temperature=40C

Sr No.0126 Voltage=10.0V Current=0.5A Power=005W Temperature=39C

Sr No.0127 Voltage=10.0V Current=0.5A Power=005W Temperature=41C

Sr No.0128 Voltage=10.0V Current=0.5A Power=005W Temperature=41C

Sr No.0129 Voltage=10.0V Current=0.5A Power=005W Temperature=42C

Sr No.0130 Voltage=10.0V Current=0.5A Power=005W Temperature=41C

Sr No.0131 Voltage=10.0V Current=0.5A Power=005W Temperature=44C

Sr No.0132 Voltage=10.0V Current=0.5A Power=005W Temperature=41C

Sr No.0133 Voltage=10.0V Current=0.0A Power=000W Temperature=40C

Sr No.0134 Voltage=10.0V Current=0.3A Power=003W Temperature=42C

Sr No.0135 Voltage=10.0V Current=0.3A Power=003W Temperature=41C

Experimental data shows corresponding values of current and voltage and power with the impact of changing temperature. Results show a clear picture of practical working of proposed design. Temperature variation is recorded precisely.

Conclusion

Solar energy paved path to continuous energy supply demolishing fear of declining energy reserves. Control Panel presented unquestioned performance recording voltage and current with temperature variations displayed using Hyper Terminal application programmed and compiled in PCW. Recorded data exhibits slight increase in short circuit current and large decrease in open circuit voltage at high temperatures with degraded efficiency consistent to theoretical results.

Nomenclature

A	Surface Area
AC	Alternating Current
DC	Direct Current
FF	Fill Factor
Im	Maximum Power
Isc	Short Circuit Current
MAX	Maxim
PC	Personal Computer
PCW	PIC C Compiler
Pm	Maximum Power
Pmea	Measured Power

[1]Voltage, current and power coding omitted intentionally

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PV	Photo Voltaic
S	Solar Irradiance
STC	Standard Test Conditions
Voc	Open Circuit Voltage
Vm	Maximum Voltage
Ƞm	Module Efficiency
Ƞp	Normalized Output Power Efficiency

Acknowledgments

None.

Conflicts of interest

None.

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