CLOUD FOR MONITORING AND LOGGING SOLAR ENERGY AND BATTERY USAGE

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ABSTRACT

Data Acquisition Systems (DAS) can be used to gather changing energy parameters derived from various energy sources. This paper discusses how Arduino based data acquisition systems (DAS) can be used to gather solar energy samples and battery level information for remote monitoring and storage in the cloud. Arduino code was developed on Arduino IDE. An open source third party application was used to capture the Arduino serial transmitted values onto a Dropbox folder where it can be shared via Internet. Arduino hardware is connected to the four small 5 V, 1 W solar panels that are loaded with properly calculated resistors and a designed battery level sensor circuit. Solar energy values and battery usage pattern values were successfully stored into Dropbox for monitoring via cloud.

KEYWORDS: DAS, data acquisition, solar energy.

1. Introduction

Solar another source of clean energy, i.e. it is used without a damage to the ozone layer. Solar energy system was proved to be cheaper over a long term even though the initial costs are high. Amongst many factors that create challenges during the design of solar energy systems is the lack of energy stability. It is therefore important to do proper feasibility study prior design. In the feasibility study, daily solar energy patterns have to be analyzed and considered. Monitoring available solar power and battery levels will enable users to predict the times when the solar units will fail to deliver energy. Guidelines for using Dropbox in system design and cloud were outlined in [1]. Various techniques to collect, study, model and monitor solar data have been used. A model was presented by [2] for solar data collection and its ability to reduce uncertainty from between 2% to 5% . Other experts have [3] performed a case study on an experimental data collection system in Northern Cyprus. DAS was also used in the agricultural sector to aquire solar data and transmit over wireless network [4]. Meteorological and data derived from satellite were also evaluated for estimatimation of solar irradiance over Malaysia [5]. Centers such as NREL [6] offers solar energy records that can be very useful during the design of solar units. SolarGIS is one of organizations which has database that contains information that is used during the design of renewable energy. The information contained is sold to the costomers [7].

2. Objectives

The main objective is to use a DAS to save solar energy samples and battery levels for sharing in a Dropbox folder.

The sub-objectives are:

- To establish a simple way to monitor renewable energy resources.
- To design and build simple battery level sensor using Zener diode and solar energy sensor using small solar panels.
- To track daily the available solar energy and battery usage patterns

3. Hardware components
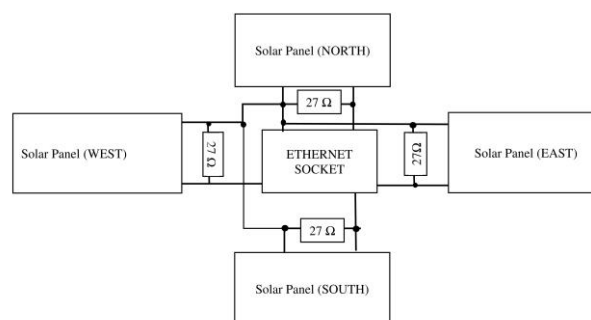
3.1 Solar sensor

Figure 1: Solar sensor block diagram

3.1.1 The value of current limiting resistors

The values of load resistors shown in figure 1 were calculated as follows:

CHN1-10P solar panels were used [8].

$$OPTIMUM\ POWER = 1W$$
$$OPTIMUM\ VOLTAGE = 5.03V$$

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$$P = \frac{V^2}{R}$$

(1)

$$1 = \frac{5.03^2}{R}$$

$$R = 25.3 \, \Omega$$

Therefore the maximum current will be:

$$P = VI \tag{2}$$

$$I = \frac{1}{5.03}$$
$$I = 0.199 A$$

3.1.2 Solar sensor hardware operation

The circuit in figure 1 represents a solar sensor diagram used detects solar arrays originating from four directions, i.e. north, east, west and south. The components act together to translate sun's beam into electrical energy. All gathered voltages are fed through the CAT 5 network cable (plugged Ethernet socket) to the Arduino board that is about 10 meters away. The cable resistance is negligible since all load resistance a connected directly to the solar panels, the cable act like volt meter probes. The Arduino board uses the derived voltages to compute the percentage of relative output energy.

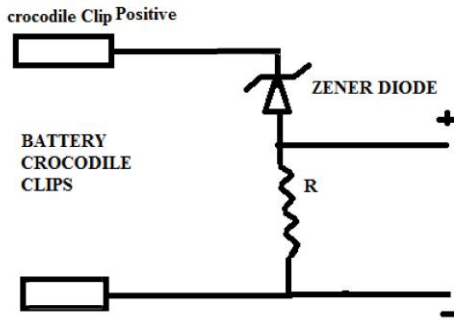### 3.2 Battery level sensor

Figure 2: Simple battery level sensor circuit

3.2.1 The value of current limiting resistor

1N4739A.BP diode was used, its specifications listed in [10].

Equations in [11] were used to do calculations of the Rs as follows:

$P_z = 1$ W
$V_z = 9.1$ V

$$P_z = \frac{V^2}{R} \tag{3}$$

$I_{zmin} = 20\%$ of rated value and $I_{zmax} = 80\%$

$$P_z = VI \tag{4}$$
$$I = \frac{1}{9.1}$$
$$= 0.\,0.10989 \text{ A}$$

$$I_{zmin} = 0.1 \times 20\% = 21.98 \text{ mA} \tag{5}$$

$$I_{zmax} = 0.1 \times 80\% = 87.9 \text{ mA} \tag{6}$$

$$R_s = \frac{R_{smin} + R_{smax}}{2} \tag{7}$$

$$R_{smax} = \frac{V_z}{I_{min}} = \frac{9.1}{21.98 \times 10^{-3}} = 414 \, \Omega \tag{8}$$

$$R_{smin} = \frac{V_z}{I_{max}} = \frac{9.1}{87.9 \times 10^{-3}} = 104 \, \Omega \tag{9}$$

$$R_s = \frac{414 + 104}{2} = 259 \, \Omega \tag{10}$$

3.2.2 Battery level sensor (hardware operation)

Fully charged battery was measured, it gave a fully charged output voltage level of 13.8 V, and the Zener used is 9.1 V [9], therefore the sensor will give a maximum voltage of 13.8V - 9.1 V= 4.7V. A voltage of 4.7 V is within the operational range for the Arduino Yun microcontroller [9]. The DC to AC Inverter was found to stop operating at an input voltage of about 11 V. The available charge percentage will be calculated by (V-battery -11V) x100 %/4.7 V, in other words 13.8V means the battery is 100 percent and 11V means the battery is 0% for operation.

4. DAS Software Code

START

Read Sensors

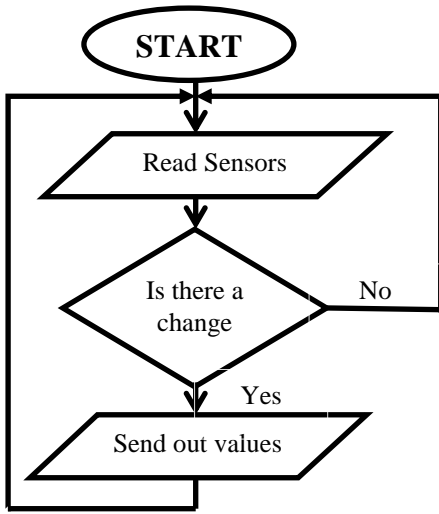Is there a change → No

Yes

Send out values

Figure 3: Flow chart

Figure 3 illustrates flow chart for the DAS software algorithm that was written in the Arduino IDE for the Arduino Yun board.

Analog inputs A0 to A4 channels were used. The micro controller check for solar level input changes every minute. If there are changes it will send comma separated values via serial communications to the host PC that runs an application which captures file onto a Drobox   folder. The Dropbox folder is shared to different parties for monitoring. As explained the values are comma separated, they can therefore be easily uploaded to the excel sheet for best analysis. Micro controllers are inputs A0 to A3 are used for acquiring outputs from the solar sensor. A4 receive battery level voltage. In the Micro controller software; the percentage of useful energy is then calculated as explained in section 3.2.2.

4. Test methods

Figure 4: Left solar sensor, Right 50 W Solar panel

Figure 4 shows a solar sensor and a 50 W solar panels mounted on the roof. The one on the left is a solar sensor which is tilted by 30° and the one on the right is a solar panel that is tilted by

30° facing north. Solar panel is 10 m away from the battery. One week solar data derived from the solar sensor and battery sensor were logged.

CHN50-40P [12], 50 W current and voltage values were also monitored using an ammeter and a volt meter respectively. See Table 1 for the sample data. The microcontroller was used to collect data from the solar sensor via its analog input channel and then it is sent to host computer that could transfer data to Dropbox. In [13] authors have suggested Dropbox [14] as the most widely-used cloud storage system.

5. Results and discussions

Table 1: Renewable energy data sample

Time	N(%)	E(%)	W(%)	S(%)	Battery (%)	
07:27:58	3.57	14.29	0	0	87.7	11-Jun
08:03:59	14.29	14.29	0	0	87.7	
09:34:05	32.14	32.14	3.57	14.29	87.7	
09:58:16	57.14	89.29	32.14	32.14	87.7	
11:40:17	57.14	57.14	32.14	32.14	87.6	
12:09:19	57.14	57.14	32.14	32.14	87.6	
13:16:21	57.14	57.14	32.14	14.29	87.6	
13:57:37	32.14	14.29	32.14	3.57	87.6	
15:03:41	14.29	14.29	32.14	3.57	87.6	
16:32:50	3.57	3.57	0	0	87.6	
07:39:52	0	0	0	0	86.8	12-Jun
08:01:58	3.57	3.57	0	0	86.8	
08:23:59	0	0	0	0	86.8	
09:04:14	14.29	14.29	3.57	3.57	86.8	
10:05:34	0	0	3.57	3.57	86.8	
11:00:51	89.29	89.29	32.14	57.14	86.8	
12:16:14	0	0	0	0	86.6	
13:14:20	3.57	3.57	3.57	3.57	86.6	
13:35:21	0	0	0	0	86.6	
14:51:27	0	0	3.57	3.57	86.6	
15:01:28	3.57	3.57	3.57	3.57	86.6	
15:31:30	0	0	3.57	3.57	86.6	

It is observed from Table 1 that the battery is discharged at a slow rate as the inverter is off. Some sample data were recorded in the morning 07:00 and 10:00, some from 11:30 to 14:00 and from 14:00 till 16:30 in the evening. The reason is that an inverter can only be used when the national grid power is not available. During testing, the National grid power was active and the inverter was off. It is also observed that a lot of energy should have been acquired on June 11 under clear sky, compared to June 12 that was partly cloudy. The sensor value were verified by calculating the power of the Solar using P = VI and P = rated power multiplied by the percentage derived from sensor. E.g. When the north solar reading from solar sensor was 57.14 %, the current from the big panel was 1.9 A corresponding to 14.6 V. VI = 27.74 W and is compared to 57.14 % of 50 W which is 28.57W. Discrepancies in values result from factors such as tilt angle, dusting, age of a panel, load, etc.

7. Conclusions

Small solar panels such the CHN1-10P [8] can be utilized to build solar sensor that will be used to detect the amount of available solar energy. Basic battery level sensor can be built by utilizing a Zener diode that is connected in series with a current limiting resistor. Micro controllers together with developed computer application program can used to capture sensor derived slow changing data onto Dropbox for easy sharing and monitoring.

8. Acknowledgements

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