Climate Monitoring Station by Solar Power

Trinh Quang Dung[a*] , Trieu Van Thang[a], Pham Minh Tien[**]

[a*] Solarlab – Department of Solar Energy Technology, Vietnamese Academy of Science and Technology
[**]Department of Electronic Applied, 1 Mac Dinh Chi Str, 1 Dist, Ho Chi Minh city
Tel: (84) 8222028, Fax: (84) 8295905, Email: solarlab@vast-hcm.ac.vn

ABSTRACT

Monitoring station is a very important role for investigation of a lot of subject. Many main positions for monitoring data base located in remote region which have no electricity. This paper presents the design and working principle of a climate monitoring station system of photovoltaic. It is essential to take the survey and observation on environmental temperature, air humidity, salinity, solar radiation and solar parameters of solar station. The data are used not only for fundamental researches but also for forecasting, and making development plan of the region such as: Agriculture (Photosynthesis), Astronomy, Atmospheric Science (Numerical Weather Prediction), Climate Change (Energy Balance), Hydrology (Evaporation), Materials (Degradation), Photobiology (Light and Life), Renewable Energy (Sustainability)

Keywords: *Design, Photovoltaic, climate monitoring by solar power.*

1. INTRODUCTION

This paper presents the most efficient application of solar electricity as is a climate monitoring station by solar power in Vietnam. The climate monitoring station measures a lot of climate parameters such as: humidity, salinity, temperature, solar radiation, and other parameters. These signals are measured as DC voltage then will be converted from DC voltage to DC current (4-20 mA) by transducers. After that they will be converted to digital signal for programmable (software) and saved to microcontroller until we collect it to the computer. The power supply to this system from the solar system, the charge controller controls the energy from the solar array and store in the battery bank for use.

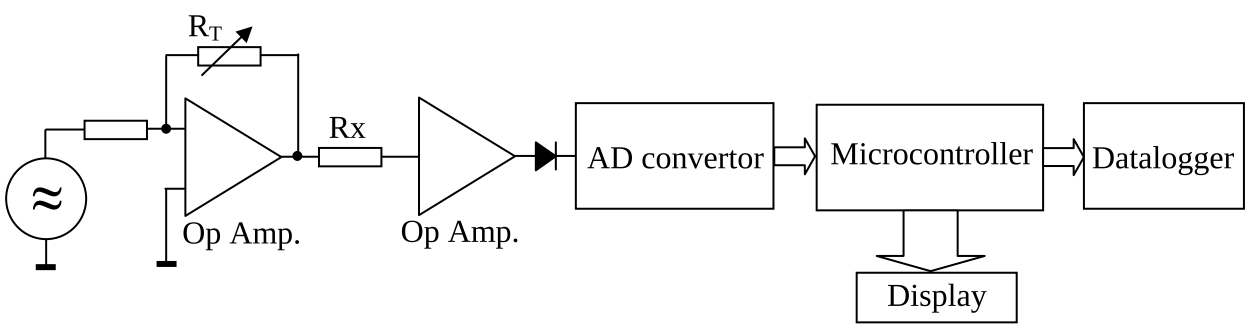

Fig. 1 Typical circuit diagram of monitoring system

2. DESIGN OF CLIMATE MONITORING STATION

2.1 Calculation of the system configuration.

The photovoltaic power system was designed based on the total energy demand per day and peak sun hours at design tilt. Therefore, a climate monitoring station powered by PV is very interesting for setting up.

In Vietnam, the solar radiation is quite good and potential. The average total solar radiation is about 5KW/h/m^2/day in almost Middle and Southern provinces of Vietnam. In the Northern provinces, the solar radiation is lower, about 4KW/h/m^2/day approximately.

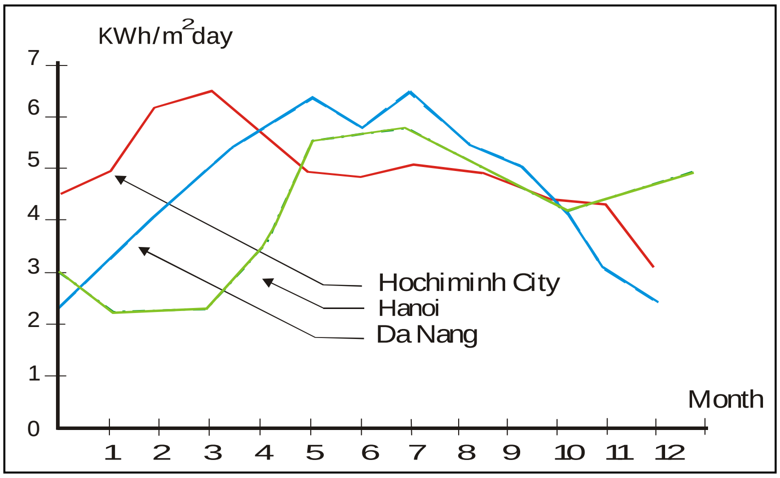

Fig. 2 Solar Radiation in North, Middle & South of Vietnam

The steps of system calculation as following:

- *Loads:*
  (1) Calculating the load: $P_{Load} = \Sigma\ DC_{Load} + \Sigma AC_{Load} \times \eta_{Inverter}$
  (2) Calculating the total loads/day: $P_{total} = P_{Load}$ x hours.
  (3) Calculating the total amp-hour demand per day: $A_{total} = P_{total}$ /battery bus

- *Battery sizing*:

  (4) Calculating the required battery capacity: $B_{capacity} = A_{Total} \times (3/0.8)$

- *Photovoltaic array sizing:*

  (5) Calculating the required output per day: $P_{PV\text{-}output} = P_{Total} / (0.75)$.
  (6) Selected PV module power output at STC: P
  (7) Calculating the energy output per module per day: P_{module} = P x peak sun hour.
  (8) Calculating the number of modules required: (7) multiply by derating factor (0.8 for hot and critical climate; 0.9 for moderate and non-critical climate)

2.2 Solar power -Madicub

The climate monitoring station by solar power is shown in fig. 3. The power of the climate monitoring station is supplied by a Madicub 1000. charging controller - Solarlab has 4 channels with charging current 25Amax per each channel. The inverter is a Smart high frequency technology and true sine wave type. The Madicub provide 12VDC and 220VAC which well responses for all requests of the monitoring station. The specifications of Madicub 1000 is shown in the table below:

Table 1 Specifications of Madicub 1000

Model	**Smart 1000**	
Continuous Power	**1000W**	
Surge Power	**3300W/ 50ms**	
Battery	**12VDC**	
Prize		
Output		
Waveform	**True Sine Wave**	
Voltage	**220V AC ± 3%,**	
Frequency	**50 Hz ± 1%**	
Efficiency	**90 %**	
Protection	**Overload, Low voltage**	
	Reverse Battery's pole - DC Fuse will break	
Led Indicator	**Inverter On, Overload**	
	Battery level	
Dimension (W x D x H) mm		
Net weight (kg)	**10**	**13**
Guarantee Time	**12 months**	

2.3 Climate monitoring station (CMS)

For monitoring of climate's factor we use different converter modules as: wind speed, solar radiation, temperature, etc. Of course, each converter need a good sensor with high accuracy through the converters, all analog signals became digital signals recorded in data logger. When digital signals to a computer with suitable software, we have all information of the system. The recording result of CMS is recorded by minute, hour per days. They are the database with high value for scientists in planning work, researching, prediction, etc.

The fig. 3 shown the schematic block circuit of the climate monitoring station.

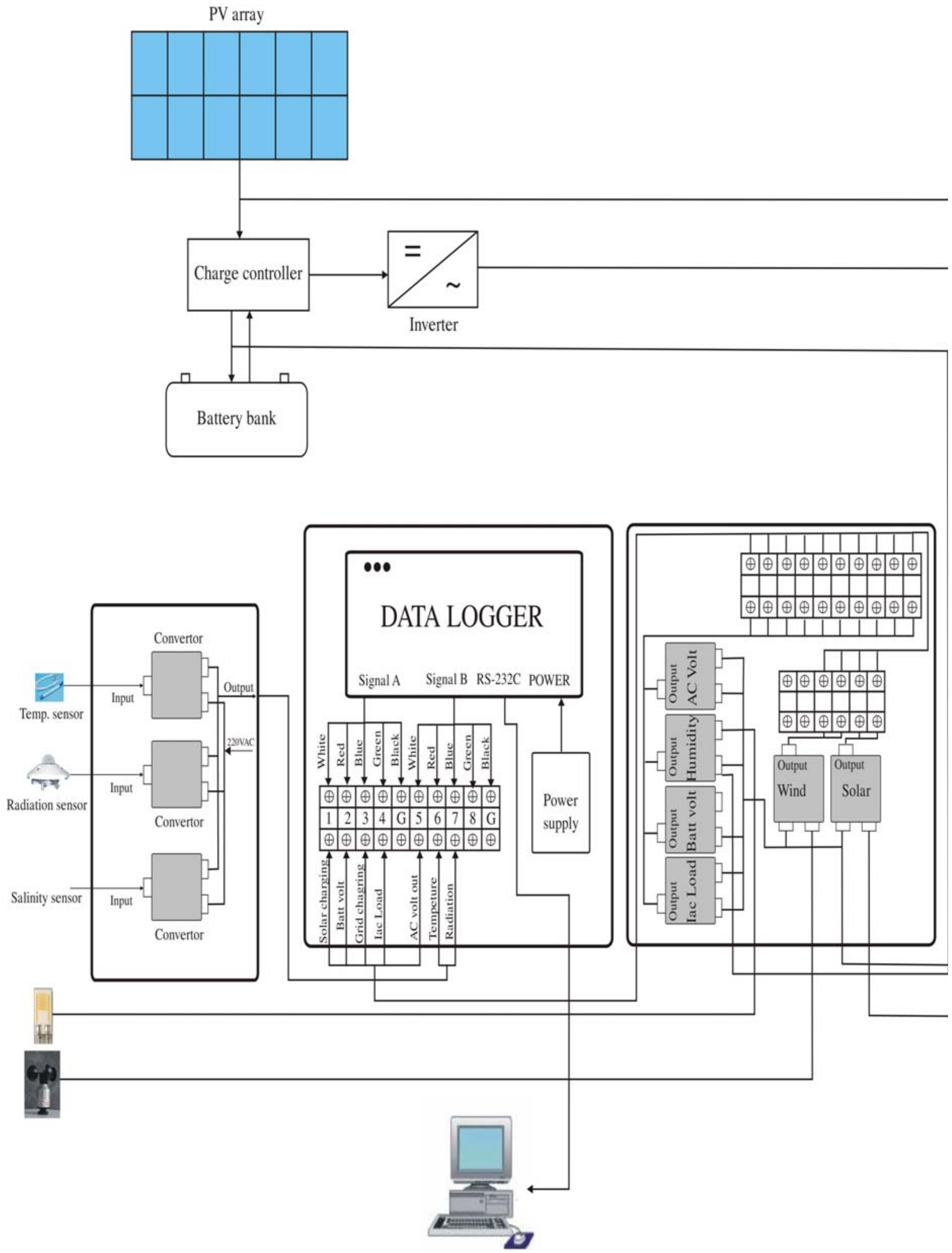

Fig. 3 Schematic block circuit of climate monitoring station

2.4 Database of the CMS

The general parameters of CMS are measured and shown in Table 2.

Table 2: parameters of CMS

Electrical parameters:	
DC, AC voltage of PV array	(V)
DC, AC current of PV array generated (Max power)	(A)
DC voltage of the battery	(V)
DC current of battery charging	(A)
Ambient Temperature	(^{0}C)
Humidity	(%)
Salinity	(pH)
Wind speed	(m/s)
Solar radiation	(W/m^2)

Technical parameters of the component in CMS.

- *Transducers:*

- Radiation transducer.
  - Input: 0 - 15mV
  - Output: 4 - 20mA
  - Power: 220VAC
  - Range: 0 – 6KW/m^2

- Salinity transducer.
  - Input: 0 - 15mV
  - Output: 4 - 20mA
  - Power: 220VAC
  - Range: 0 – 14pH

- Humidity transducer.
  - Input: 0 - 15mV
  - Output: 4 - 20mA
  - Power: 220VAC
  - Range: 0 – 100%

- Temperature transducer.
  - Input: PT - 100Ω
  - Range: 0 – 100^{0}C
  - Output: 4 – 20mA
  - Power: 220VAC

- DC milivoltage transducer.
  - Input: DC: 0 - 20mV
  - Output: DC :4 - 20mA
  - Power: 220VAC

- Voltage transducer.
  - Input: AC: 0 - 300V
  - Output: AC :4 - 20mA
  - Power: 220VAC

- *Analog digital converter and microcontroller (data logger):*

The analog input channel and differential gain are selected by writing to the MUX bits in ADMUX. Any of the ADC input pins, as well as GND and a fixed bandgap voltage reference, can be selected as single ended inputs to the ADC. A selection of ADC input pins can be selected as positive and negative inputs to the differential gain amplifier. If differential channels are selected, the differential gain stage amplifies the voltage difference between the selected input channel pair by the selected gain factor. This amplified value then becomes the analog input to the ADC. If single ended channels are used, the gain amplifier is bypassed altogether.

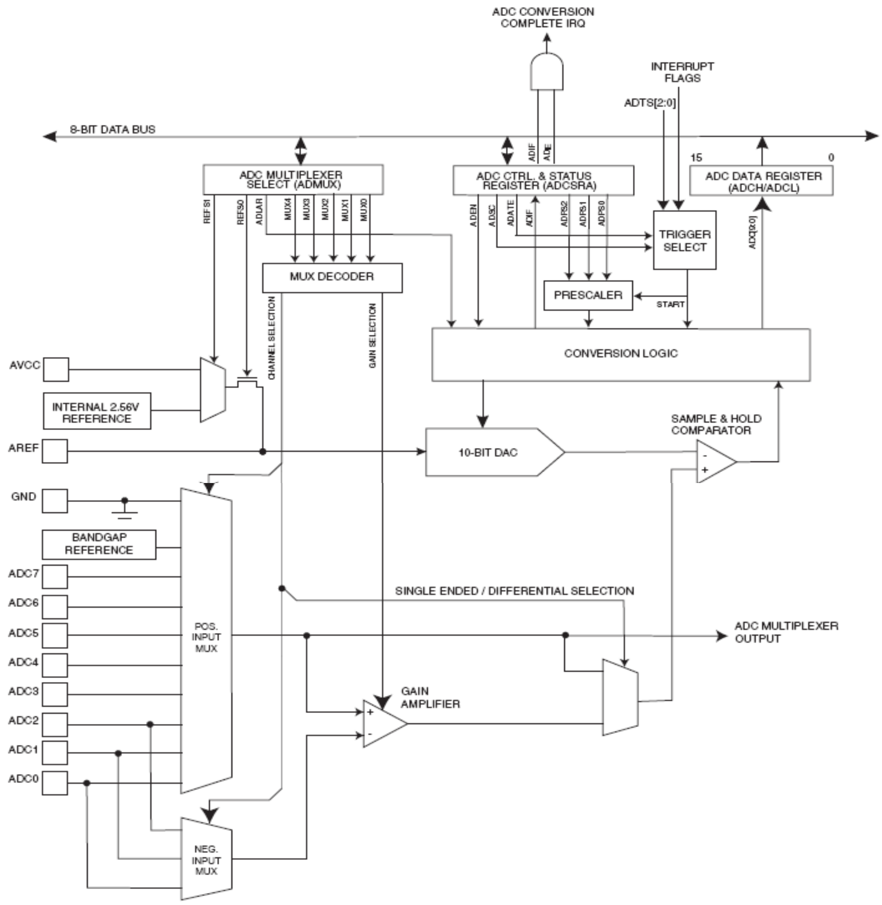

Fig. 4 block scheme of converting process from analog signal into digital

The fig. 5 shows the microcontroller block schematic which is a low-power CMOS 8-bit microcontroller. The microcontroller provides the following features: 8K bytes of In-System Programmable Flash with Read-While-Write capabilities, 512 bytes EEPROM, 512 bytes SRAM, 32 general purpose I/O lines, 32 general purpose working registers, three flexible Timer/Counters with compare modes, internal and external interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain in TQFP package, a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next interrupt or Hardware Reset. In Power-save mode, the asynchronous timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except asynchronous timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the asynchronous timer continue to run.

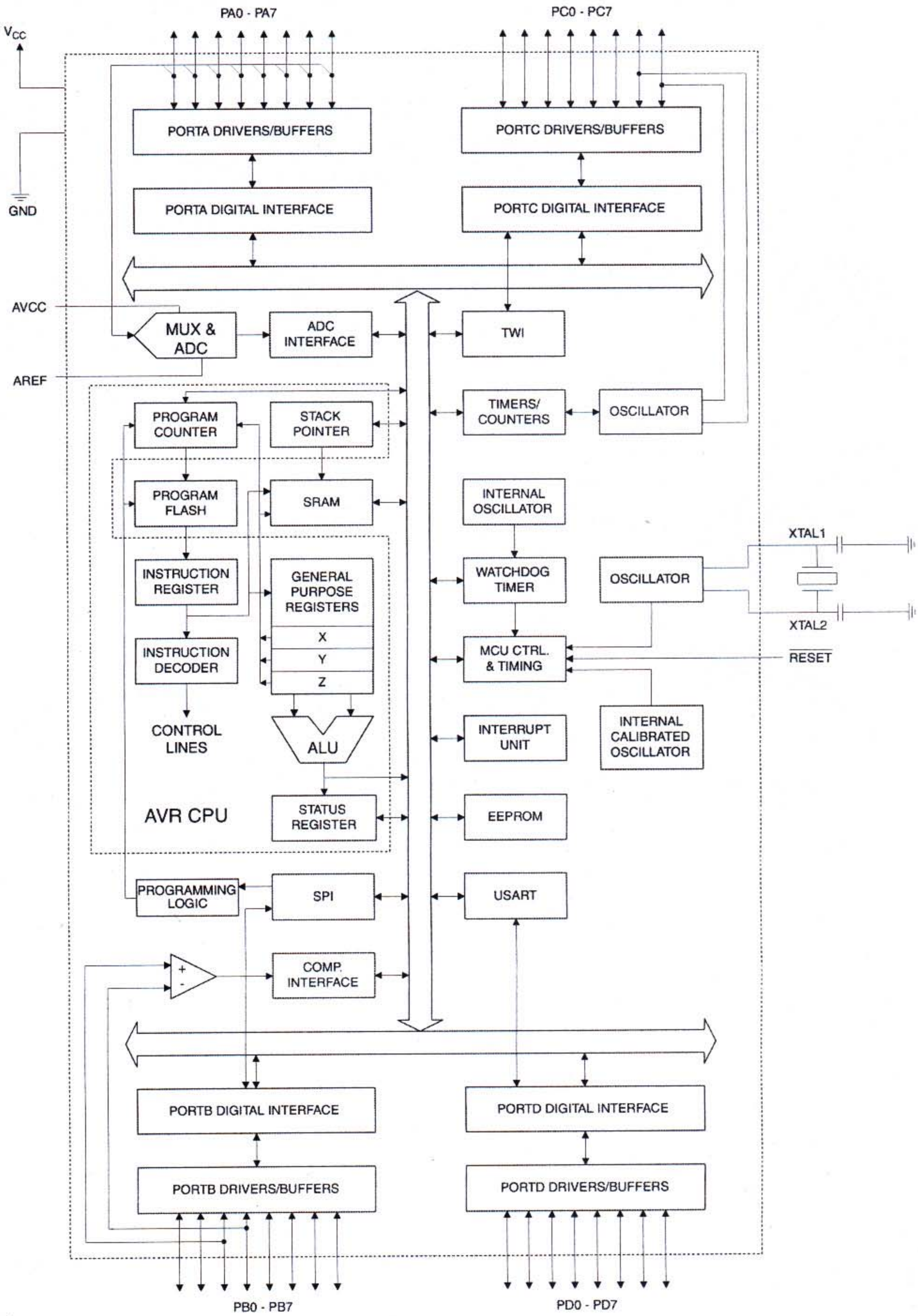

Fig. 5 Microcontroller block schematic

3. APPLICATION OF THE CLIMATE MONITORING STATION

3.1 Salinity monitoring

Fig. 6 shows the result of salinity measuring in the different level of water in a day. In Vietnam have a long coast and an interlacing system of rivers and canals, especially in the South of Vietnam. It is the reason why the researches on the fundamentals of hydrology and pedology play a very important role, this result measure on 26 Dec 2007.

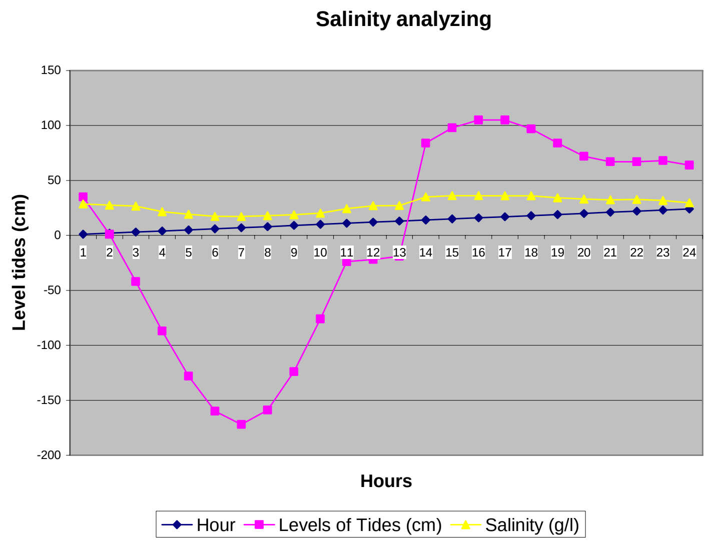

Fig. 6 Measurement of salinity

3.2 Solar house monitoring

The next application of monitoring station is a solar house located in Nhat Chi Mai Str, Tan Binh Dist, HCMC. The table 3 shows the total loads in the solar house, the monitoring station will measure and monitor the charging current from the solar array, battery voltage, and load current all the day every half hour. The fig. 7 shows the battery voltage and the charging current in the day, this data measured on 1 April 2007

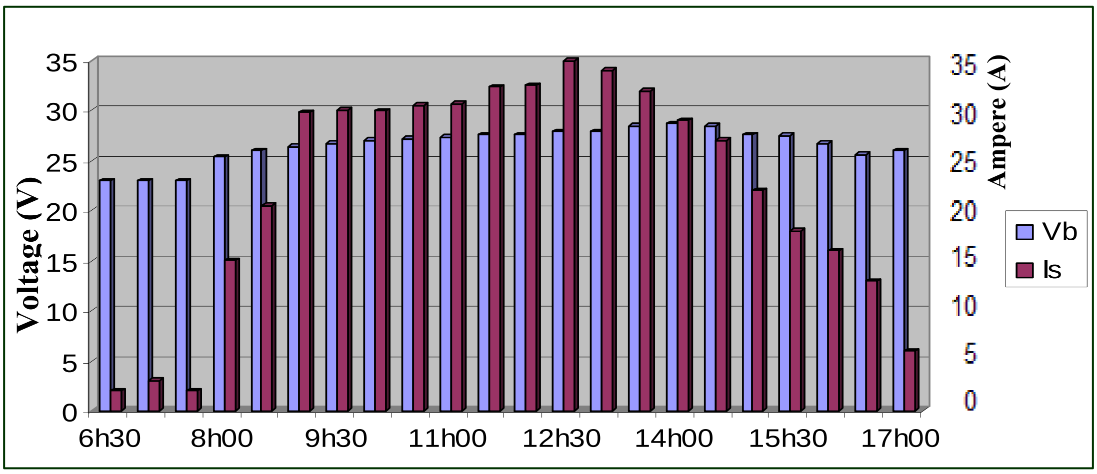

Fig. 7 The average charging current and battery voltage

Table 3 The electrical appliances in solar house

No	Appliance	Qua	Power 220 VAC	Operation Time/day	Consump day
A	**LIGHTING**				
1	Lamp 1.2 m	4	40W	10 hours	400W
2	Lamp 60 cm	6	20W	4 hours	80W
3	Decoration light	2	200W		
4	Security Garden Lighting	1	5W	12 hours	60W
B	**PUMPING**				
5	Irrigation Garden Pump	1	250W	15 min	62.5W
6	Pump of artificial water fall	1	250W	20 min	83.3W
7	Well Water Pump	1	750W	1.5 hours	1125W
C	**COOLING FREEZING FACILIGY**				
8	Fridge 60 liter Sanyo	1	60W	10 hours	600W
9	Mobil air conditioner	1	760W	4 hours	3040W
D	**INFORMATICS**				
10	Photocopy HP 1100 A	1	350W	10 min	58.3W
11	PC system Pentium IV	1	250W	8 hours	2000W
12	HP 1100A Printer	1	330W	15 min	82.5W
E	**AUDIO AND VIRUAL FACILITY**				
13	Radio-cassette system	1	100W	1 hours	100W
14	VCR, DVD Head	2	17W	1 hours	17W
15	Color TV 29”	2	1500W	5 hours	7500W
F	**FRESH AIR**				
16	Standing fan	1	55W	4 hours	220W
17	Ceiling fan	1	150W	4 hours	600W
G	**BOILING**				
18	Tea Pot	1	600W	15 min	150W
19	Coffee Maker	1	700W	10 min	117W
20	Hot Pot	1	600W	30 min	300W
I	**COMMUNICATION**				
21	Radio telephone Mobile	1	60W	4 hours	240W
22	Mobile	1	15W	1.5 hours	22.5W
K	**OTHER**				
23	Rolling door	3	150W	5 min	12.5W
24	Gymnastic machine	1	500W	30 min	250W
25	Villa a alarm	1	10W	10 min	1.7W
		TOTAL			**17,122 kW**

The fig. 8 shows the charging current, battery voltage, and the loads current measured on 25 April 2006
V_b: Battery voltage
I_s: Charging current
I_t: Load current

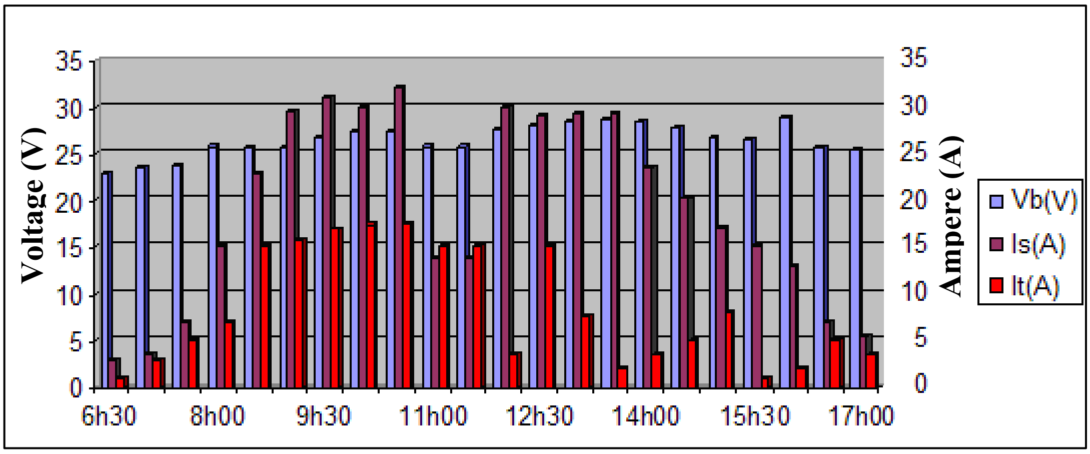

Fig. 8 Solar house monitoring parameters

3.3 Solar cultural house monitoring

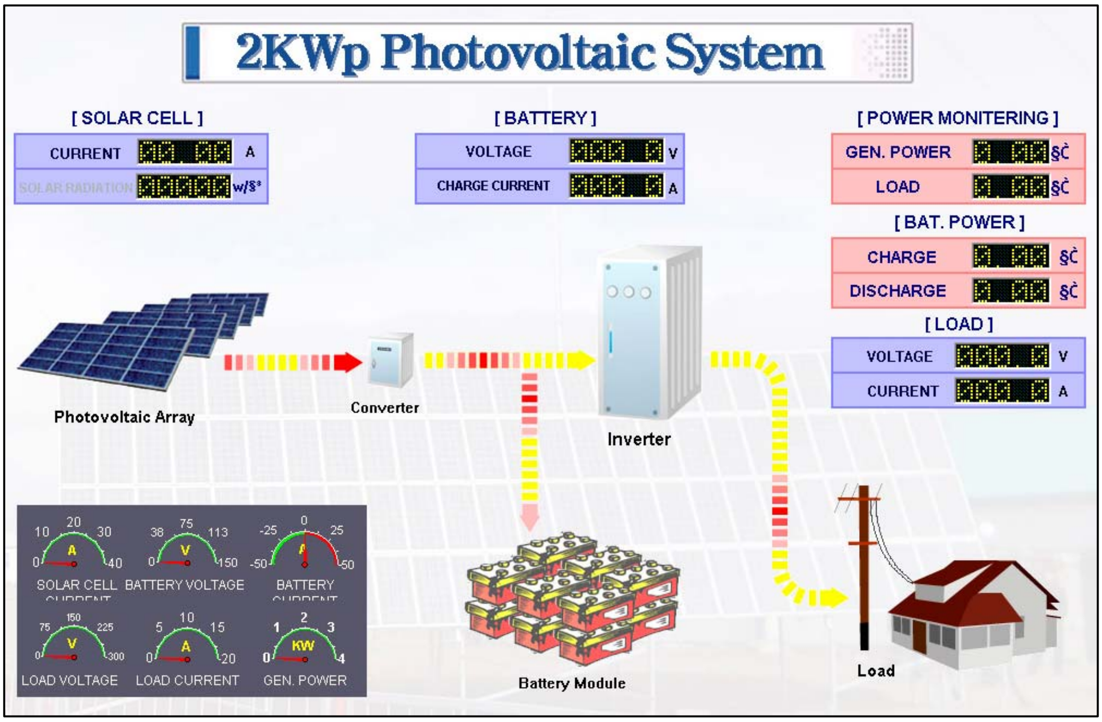

Fig. 9 The display screen of monitoring station

The most successful application of climate monitoring station is a cultural house located in Binh Phuoc province. The monitoring station monitors the parameters of the solar system, solar radiation, and the ambience temperature.

The fig. 9 shows the display system operation of 2 kWp photovoltaic, all these data will be measured every minute and stored in 3 -4 months belong to the data logger memory.

The table 4 shows the data measured of the solar system in an hour in the day. The monitoring station measures and stores all the data every minute in the data logger until we collect it.

Table 4. The data measured of the solar system in an hour in the day

Time	Sol. Current (A)	Bat. Voltage (VDC)	Charge Current (A)	Load Current (A)	Load Voltage (VAC)	Temp (^{0}C)	Sol. Radiation (W/m^2)	Gen. Power (KW)	Load Power (KW)
06:07	3.8	52.5	0	0.5	218.3	26	20	0.2	0.11
06:08	3.8	52.5	0	0.5	218.4	26	22	0.2	0.11
06:09	3.8	52.5	0	0.5	218.2	26	23	0.2	0.11
06:10	4.1	52.6	0	0.3	218.5	26	25	0.22	0.07
06:11	4.3	52.6	0.1	0.2	218.7	26	26	0.23	0.05
06:12	4.3	52.7	0.2	0.2	218.7	26	28	0.23	0.05
06:13	4.3	52.6	0.5	0.2	218.7	26	30	0.23	0.05
06:14	4.3	52.6	0.7	0.2	218.8	26	32	0.23	0.05
06:15	4.3	52.6	0.7	0.2	218.7	26	34	0.23	0.05
06:16	4.4	52.6	0.7	0.2	218.7	26.5	38	0.23	0.05
06:17	4.4	52.6	0.9	0.2	218.7	26.5	39	0.23	0.05
06:18	4.4	52.6	0.9	0.2	218.8	26.5	40	0.23	0.05
06:19	4.4	52.6	0.9	0.2	218.6	26.5	40	0.23	0.05
06:20	4.4	52.6	0.9	0.2	218.6	26.5	42	0.23	0.05
06:21	4.4	52.6	1	0.2	218.7	26.5	44	0.23	0.05
06:22	4.5	52.5	1.1	0.2	218.8	26.5	47	0.24	0.05
06:23	4.5	52.5	1.2	0.2	218.7	26.5	51	0.24	0.05
06:24	4.6	52.5	1.3	0.2	218.8	26.5	53	0.24	0.05
06:25	4.5	52.6	1.5	0.2	218.8	26.5	52	0.24	0.05
06:26	4.5	52.6	1.2	0.2	218.8	26.5	53	0.24	0.05
06:27	4.6	52.5	1.6	0.2	218.7	26.5	55	0.24	0.05
06:28	4.6	52.5	1.8	0.2	218.6	26.5	57	0.24	0.05
06:29	4.6	52.5	1.8	0.2	218.7	26.5	59	0.24	0.05
06:30	4.6	52.5	1.9	0.2	218.7	26.5	61	0.24	0.05
06:31	4.7	52.5	2	0.2	218.7	26.5	63	0.24	0.05
06:32	4.7	52.5	2	0.2	218.7	27	64	0.25	0.05
06:33	4.7	52.5	2.1	0.2	218.8	27	65	0.25	0.05
06:34	4.7	52.5	2.2	0.2	218.5	27	66	0.25	0.05
06:35	4.7	52.5	2.3	0.2	218.6	27	68	0.25	0.05
06:36	4.7	52.5	2.5	0.3	218.7	27	69	0.25	0.05
06:37	4.8	52.5	2.6	0.2	218.7	27	70	0.25	0.05
06:38	4.8	52.5	2.7	0.2	218.6	27	72	0.25	0.05

4. CONCLUSION

Database of climate is very important in research and development of a country. Because of lacking electricity the database could not be recorded in every positions as requested. The Climate Monitoring Station by solar is a new tool for scientists to build database everywhere they need. With tise advantage, Solarlab is in processing to build the first National Climate Monitoring Station in Nam can-Camau province(southern of Vietnam) during 2008-2010. All the data will be measured by minutes, hours etc on request and collected every month to analyze for building a database of the region which helping socio-economic development of Vietnam.

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