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Experimental Device for Acquisition of Propertiesi-V and V (T) of the Solar by Automatic Change Operating Point

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Abstract: Design and implementation of a device for automation of variations of the resistive load powered by solar cell. It is provided by a PIC16F877 running a computer program that we have developed on the basis of an algorithm according to the operation that we have set.

Index Terms: Solar cell, PWM, PIC16F877,

I. INTRODUCTION

Operating a source of renewable energy [1], the PV generator [2] is a central component of the system.

Improving the efficiency of the solar cell one of the conditions for better competitiveness compared to other solar photovoltaic energy sources.

From then on, a good knowledge of the phenomenological photovoltaic process can lead to the design of solar cells [3] [4] [5] more efficient.

Mathematical models, parametric functions, are excellent tools for researchers to study qualitatively the various technologies design solar cells.

However the experimentation must confirm the theory which led to the mathematical models of the photovoltaic cell.Thus, the use of a practical device for the characterization of the solar cell to identify the parameters of the equivalent model is an important step in the search for innovative solutions.In our study, we sought to automate changes in the resistive load supplied by the solar cell.The microcontroller [6] runs a program [7] [8] that we designed computer based on an algorithm according to the operation that we have set.

II. AUTOMATICVARIATIONOFTHESOLAR CELL RESISTIVELOAD

The device we designed takes a principle diagram widely used for the static characteristic of the solar cell.

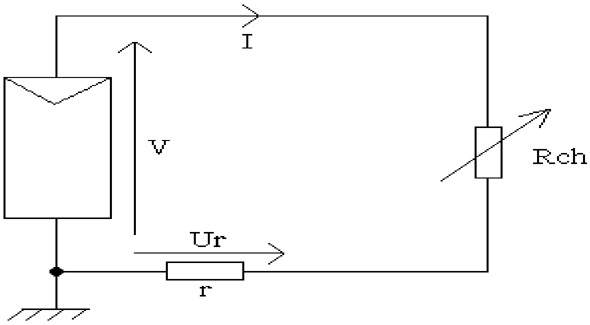

Figure 1: Basic scheme for characterization of the solar cell

In our device, only one assembly is used to study the static and temporary mode. Indeed, the program executed by the microcontroller is composed of two sub-programs, each corresponding to a mode. Thus, an action on a wired switch to one of the microprocessor inputs allows choosing the modeto be studied.

2.1. Automation device of the variation of solar cell resistive load

Our solution is to remotely control an equivalent electrical resistance value; this, using digital electronics [12] [13] (Figure 2).

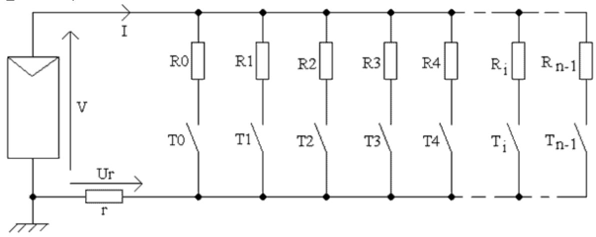

Figure 2:*Basic scheme for solar cell automatic characterization*

R_i, are the resistances that can participate in the parallel association. Value of the equivalent resistance is the following: $\frac{1}{R_{eq}} = \sum_{i=0}^{n-1} T_i . \frac{1}{R_i}$ (1) With $T_i = 0$ Resistance R_i is not part of the association, for $T_i = 1$, Resistance R_i is not part of the association)

We have a digital function with n binary variables:

$R_{eq} = f\left(T_0, T_1, T_2, ...T_{n-1}\right)$ (2)

This digital function has a N number countable of set values. The following expression expresses N as a function of n [14] and for relations $N = 2^n$.

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As a result, with our solution using n electronic switches provides 2^n distinct operating points. For example, with 8 resistances, we have 256 possible values for the load resistance of the solar cell; this also corresponds to 256 torque measurements of the solar cell current-voltage.

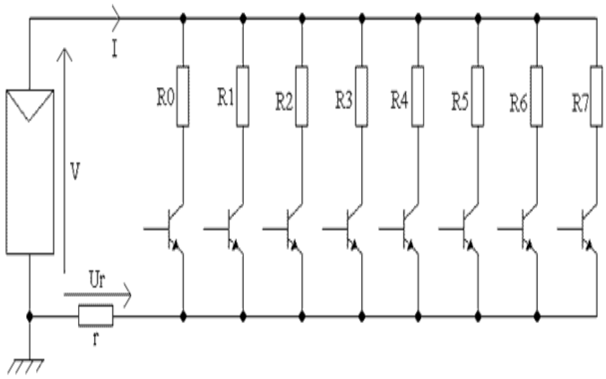

Figure 3:*Schematic diagram for the solar cell automatic characterization*

For our equivalent resistance, binary signals are generated by a sequencer and applied to the transistors, setting resistance value. It's so a digitally controllable resistance is designed.

The sequencer, control part, can be wired with sequential logic components such as counters, registers (Figure 5). Using of a programmable sequencer such as microcontroller (Figure 6) allowed us to make our flexible experimental device with several operating modes.

2.2. Control laws of the digital control resistor

The sequencer controls them transistors through binary digits which obey logic.

To obtain a law of order, we define B binary number having as numbers them binary variables associated with n switches: $B = T_{n-1}...T_i...T_0$ (3)

That D is the decimal representation of the binary B $((D)_{10} = (B)_2)$ (4), and we obtain [26]:

$D = T_{n-1}.2^{n-1} + ...T_i.2^i + ... + T_0.2^0$ (5)

D is a natural entirety with 2^nvalue definite:from 0 to $2^n - 1$. Expression (1) of digital equivalent resistance we reveal the D number in the following way:

$$\frac{1}{R_{eq}} = \frac{T_{n-1}.2^{n-1}}{R_{n-1}.2^{n-1}} + \frac{T_{n-2}.2^{n-2}}{R_{n-2}.2^{n-2}} + ... \frac{T_i.2^i}{R_i.2^i} ... + \frac{T_0.2^0}{R_{0.}2^0} \quad (6)$$

Thenwe pose $R_i.2^i = R_0.2^0 = R_0 \quad \forall \quad i$:

$$\frac{1}{R_{eq}} = \frac{1}{R_0}\left(T_{n-1}.2^{n-1} + ...T_i.2^i + ... + T_0.2^0\right) \quad (7)$$

By identifying the number D, the equation is written: $R_{eq} = \frac{R_0}{D}$ (8)

We obtain our laws of order thus binding the regulated size (R_{eq}) to the size regulating (D). The arbitrary choice of the value of a resistance enables us to calculate the values of the n-1 remaining resistances using the relation of following recurrence:

$$\frac{R_i}{R_{i+1}} = \frac{R_0}{2^i}.\frac{2^{i+1}}{R_0} \quad (9) \text{and } R_i = 2.R_{i+1} \quad (10)$$

✓Case of the device with 8 resistances

Here, $n = 8$ and we choose arbitrarily $10\ \Omega$ for resistance R_7 who is weakest. The equation of recurrence (10) allows the calculation of the values of7 other remaining resistances:

Tableau 1: Values of balanced Resistances

R_7	R_6	R_5	R_4	R_3	R_2	R_1	R_0
10 Ω	20 Ω	40 Ω	80 Ω	160 Ω	320 Ω	640 Ω	1280 Ω

The law of order is: $R_{eq} = \frac{1280}{D}$ (11)

2.3. Sequencer of resistance to digital control

For the ordering of resistance, we worked out a first sequencer cabled with Bascule D; then a second programmable sequencer with a microprocessor.

2.3.1. Cabled sequencer of resistor to digital control

The diagram containing 8 bascules corresponding to the number of points of operation of the photovoltaic cell to knowing 2^n (figure 5) will be replaced by the type with a microprocessor (figure 8) corresponding.

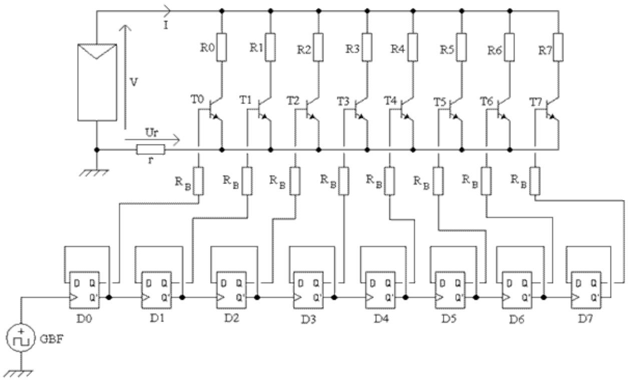

*Figure5:*Order cabled automatic experimental device for photovoltaic cell

2.3.2. Séquenceur programmable de la résistance à commande numérique

2.3.2.1.Algorithme pour la commande par le microcontrôleur PIC 16F877

The algorithm depends on the specifications which represent the operation of the device. The choice of the mode studied (static or dynamic transient) is done by a switch K_R (S_1 Is To set; S_0 is for stop)

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The complete diagram with the power part and the order part is presented below.

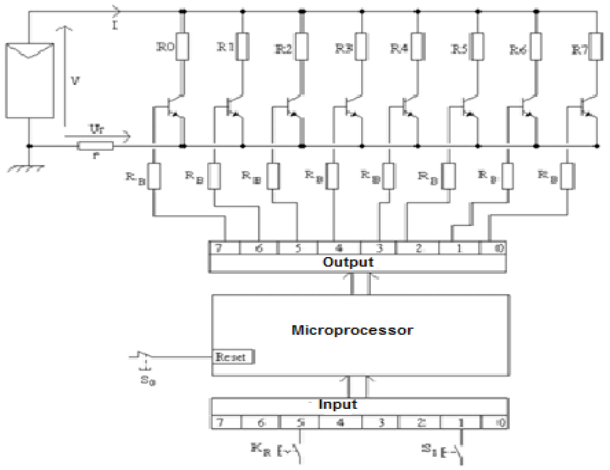

Figure 6: Programmable ordering of the automatic experimental device for photovoltaic cell

Resistor R_B , fix the basic current which orders the commutation of the transistor

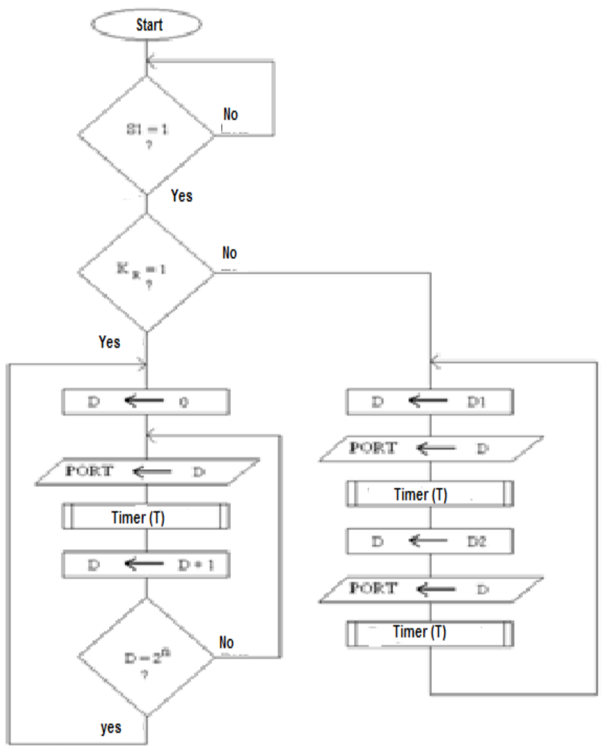

Figure 7: Algorithm for the ordering of resistance to digital control

III. AUTOMATIC VARIATION OF THE ARTIFICIAL ILLUMINATION OF THE PHOTOVOLTAGE

In this part developed an equipment-software unit to have an artificial source of light ordered by microprocessor; it is thus about a simulator of the light radiation of the sun.We chose an order by Pulse Width Modulation (PWM); such an order is binary and allows us to use only one transistor for the power part of the simulator. Only one microprocessor manages the automation of the variation of the point of operation of the photovoltaic cell, with two degrees of freedom which are the load and the illumination of the photovoltaic cell.We represented on figure 10 the synoptic diagram of the automated system illumination of the photovoltaic cell.

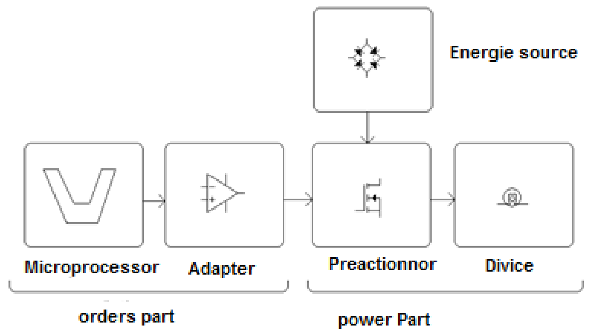

Figure 8: Synoptic diagram of the simulator of illumination

It is about a bulb supplied with D.C. current through a transistor in commutation ordered by a microprocessor through an operational amplifier functioning out of comparator.

3.1. Generation of PWM signal by microcontroller PIC

The pi16F877 have two CCp modules (capture, compare and PWM). It's the binary frequency signal whose cyclic report can be modulated. It is about a binary digit of frequency fixes whose cyclic report can be modulated Our module "PWM" will use a pine of our PIC configured at output [16].

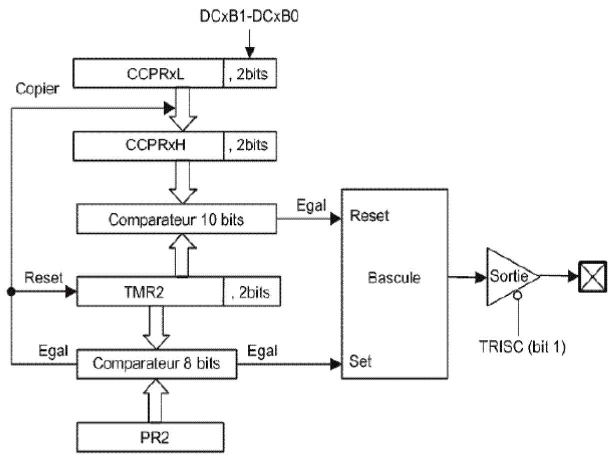

Figure 9: The PWM module of Pic16F877 microcontroller

Two registers make it possible to fix the two parameters of signal MLI, namely PR2 for the frequency of the signal and CCPRxL for the duration of the high state and consequently of cyclic report

The value of register PR2 is calculated starting from equation II

$$PR2 = \frac{Tc}{Prescaler \times 4 \times Tosc} - 1 \qquad \text{(II.20)}$$

The value of the CCPRxL register corresponds to the eight high-orders digit of variable COMPAR defined by equation II.

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$$COMPAR = \frac{Th}{Prescaler \times Tosc} \quad \text{(II.21)}$$

Where "prescaler" is an entirety whose definite values are: 1, 2, 4 and 8;

Tosc is the time of microcontroller oscillator; Tc is the time of the PWM signal and the duration of the high state of the PWM signal.

IV. EXPERIMENTAL REALIZATION OF DEVICE

4.1 Schemes of realization(seeannex figure 20)

The embodiment of the device was performed in the laboratory of physics of semi-conductorsFST /UCAD, the Training Centre for Technical and Vocational Training Senegal/ Japan, and Thies Technical College

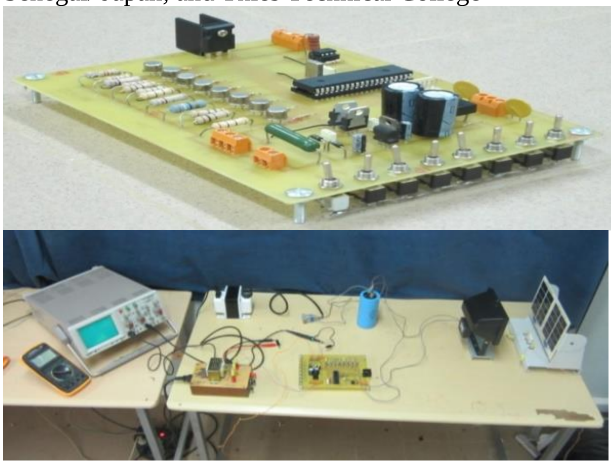

Figure 10: PCB of the experimental

4. PRESENTING RESULTS

The results are obtained with an analog oscilloscope. The microprocessor PIC 16F877 issued for the controlling part of the automatic experimental

- ✓ La tension aux bornes de l'alimentation de puissance E:

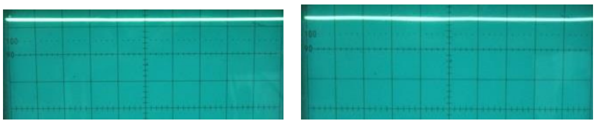

Figure 11: Curves of E (t) (50V/div and 2ms/div) for α=0% at left and α=99% in right

- ✓ PWM signal vg generating by microcontroller

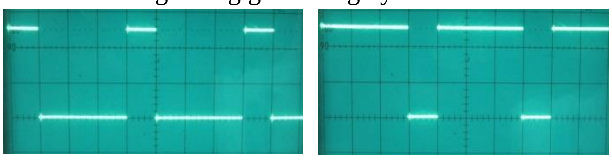

Figure 12: Curves of vg (t) (2V/div and 0,1ms/div) forα=25% at left and α=75% at right

- ✓ PWM signal Vg to the gate of the power transistor::

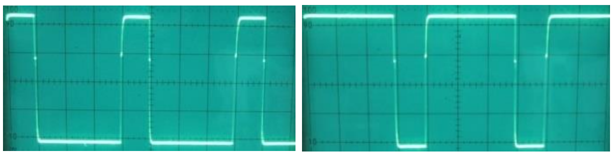

Figure 13: Curves of Vg (t) (5V/div and 0,1ms/div) for α=25% at left and α=75% at right

- ✓ The voltage U(t) across the bulb power:

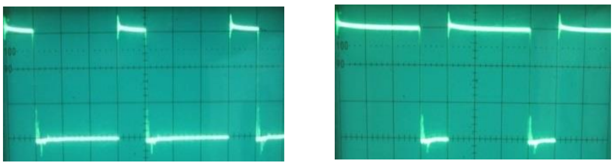

Figure 14: *Curves of U (t) (50V/div and 0,1ms/div) for α=25% at left and α=75% at right*

The voltage V (t) of the solar cell in the static	The current I (t) of the solar cell in the static
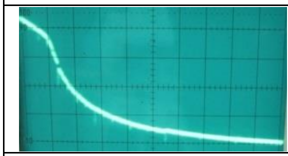	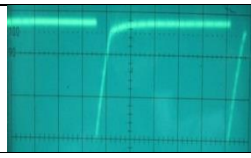
Figure 15: Diagram of the solar cell voltage for natural lighting & constant	Figure 16:Curve of the solar power for natural lighting and constant
characteristic under static constant under natural light:	Under static characteristic under constant artificial lighting:
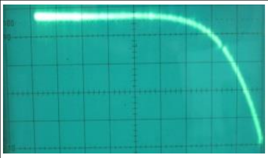	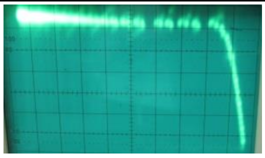
Figure 17: curves of the solar constant for natural lighting	Figure 18: curves of the solar constant for artificial lighting

✓CharacteristicV (t) underdynamictransientundernatural illumination constant:

Figure 19: Diagram of transient voltage of the solar constant and natural lighting:

V. CONCLUSION

In order to validate our work, tests were performed. We exposed oscillograms of different PWM control signals generated by the PIC16F877 and which can control opening and closing of the transistor.

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We used the notion of equivalent resistance to several resistors wired in parallel to obtain a variable resistor with digital control. The use of static switches of transistor type allowed modifying the wiring resistance of the association using electronic binary signals. The digital operation of this variable equivalent resistance conducts us using rules governing the numbering systems to obtain a control law of that resistance.

We used a microcontroller for material implementation of this control law. Finally, we also designed and produced a variable light source of binary control by Pulse Width Modulation (PWM) for a solar cell illumination. The PWM is also generated by a microprocessor, which allowed unification of variable resistor controls and variable illumination through a single microprocessor.

We can conclude that the results are suitable, regarding limitations of our equipment and resources.

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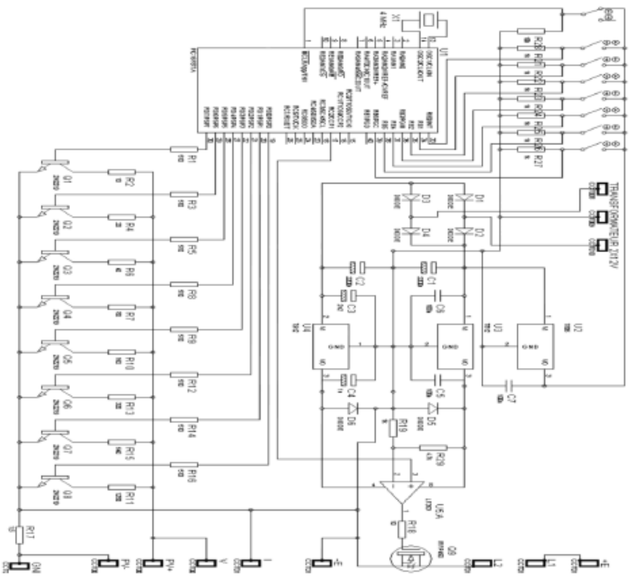

Figure 20: Diagram of the automatic experimental device for photovoltaic cell

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