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Realization of the Control of a Solar Tracker

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***Abstract* — This paper consists in the realization of a mobile system that rotates, using two DC motors, a solar panel according to both horizontal and vertical axes. The mechanical part, where the electric energy is transformed into mechanical energy by using the DC motors, is controlled by an adaptive control. The electronic part consists of a map around a microcontroller (PIC 16F877A) and a power circuit (L298N) for controlling the motors.**

***Keywords* — Solar tracker, Adaptive control, DC motor, Microcontroller PIC 16F877A, Power circuit L298N.**

I. INTRODUCTION

The growing demand for energy, the continued reduction of existing sources of fossil fuels and growing concern environmental pollution, pushed humanity to explore new technologies for the production of electricity using clean, renewable sources such as solar energy, wind energy, etc..

Among the non-conventional energy sources and renewable, solar energy offers great potential for conversion into electrical energy, able to provide a significant portion of the electric energy needs of the planet [1], [2].

Solar energy is available, clean, free and inexhaustible. Therefore, it is increasingly used as an alternative to combustion in electricity generation [3].

The objective is to improve energy efficiency for maximum capture this energy, there are several techniques, the most important technique is the installation of a solar panel on a moving system of solar tracking, the system must be rotated about a single axis or on two axes, it is better to use the two axes.

In this paper we present the design and implementation of an automatic solar tracking mobile system that turns a panel according to two axes, horizontal and vertical by using adaptive control. The description and the design of the system is followed by the implementation phase and simulation system.

II. SYSTEM DESCRIPTION

In the practical realization, you must know the basic concepts for understanding the methodology of implementation of electronic components. Documents provided by the manufacturer of components are needed to facilitate understanding some phenomena and some choices.

The electric actuator used, consists of a DC motor of 12volts, the vertical movement of the panel is provided by the arm cylinder. For horizontal movement, there was used a direct-current motor 12volts actuating the vertical axis of the solar tracker.

The mechanical reducer is used to alter the speed ratio between the inlet axis (axis of the motor) and the outlet axis (vertical axis of the tracker), the reduction in the draft is from 10 to 1. We installed on the tracker of the limit sensors to stop the motors in the final position of each rotation. The voltage +5 volts required for the logic part of the control map is generated by a voltage regulator type 7805.

The voltage regulator is an element that stabilizes the output voltage to a fixed value. It consists of a set of conventional components (resistors, zener diodes and transistors) [6].

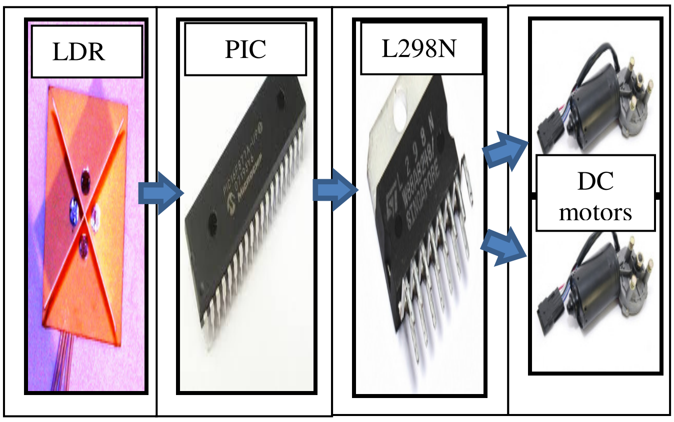

Fig. 1 The main elements for realizing a solar tracker

Track the sun can be done in azimuth (from east to west, as the advance of the day) and height (depending on season and again, the advance of the day).

In case the solar panel is not pointed at the sun, a signal is generated by the difference in tension from the four LDR. This signal is transmitted to the input of PIC16F877A microcontroller which is intended for the proper control of DC motors. The microcontroller then processes harvest four signals from four LDR and compares their tensions. So, it controls the motors that guide the panel towards the sun (Fig. 1).

III. System Design

A. Adaptive Control

The terminology "adaptive control" means a set of methods for automatic real-time adjustment of controller parameters used in a control loop to achieve or maintain a desired level of performance when the process parameters are unknown or vary time.

Adaptive control is a set of techniques that are used for automatic real-time adjustment of control loops regulators to achieve or maintain a level of performance when the process parameters to be controlled are either unknown or time varying.

The adaptive control system measures a performance index (PI) control system and from the difference between the desired performance index and the measured performance index.

The adaptation mechanism modifies the parameters of the adjustable regulator or the control signals to maintain the IP system in the vicinity of the desired values.

The adaptive control system further contains a control loop reaction-against a regulator having adjustable parameters. An additional loop, which acts on the controller parameters helps maintain system performance in the presence of variations of the process parameters. This additional loop also has a structure against the reaction where the controlled variable is the performance of the control system itself.

The realization of adaptive control only makes sense for a process for which achieve conventional control is known from a particular type of regulator. The adaptation occurs at the adjustment of the parameters of this controller or sometimes at the control signal so as to meet or maximize a performance index, which is defined by means of an adjustment mechanism [4], [5].

The adaptation mechanism operates generally as an additional feedback loop in which the controlled variable is the performance index adopted for the process (Fig. 2).

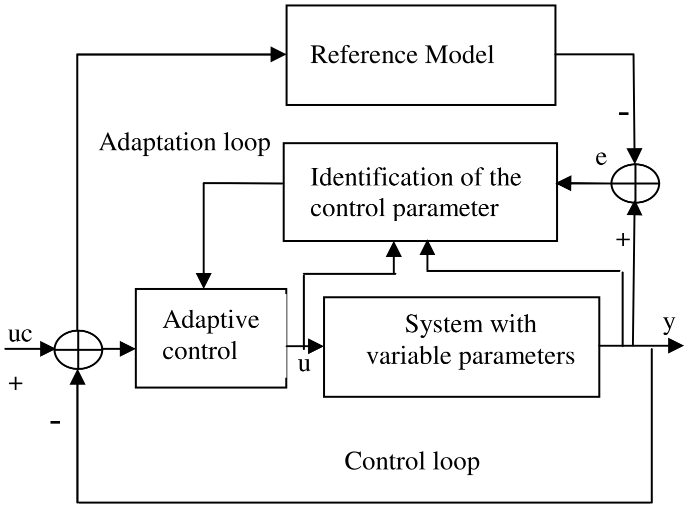

Fig. 2 Adaptive control system

B. Direct current motor

We use in our project two wiper motor of a car. These motors are DC motors of 12volts having a speed reducer for each [10] (Fig. 3).

Fig. 3 DC Motor

Use of L298N circuit for controlling the DC motor is shown in Fig. 4. This configuration is advantageous because it provides a rotating clockwise or anticlockwise. A stop with heavy braking and coasting stop occur based logic levels applied to the control inputs.

Thus, if the Enable input is high, a clockwise rotation will be obtained if the input 'C' is high and input 'D' to the low state. An anticlockwise will be achieved by reversing these two signals.

The hard braking will occur when both inputs are present even logic levels. In order to get the motor to stop coasting,

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the ENABLE input must be brought to a low level and the two control inputs at the same level (Table 1)

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TABLE I
PRINCIPLE OF OPERATING

	Inputs	Functions
V_{en}=H	C=H ; D=L.	Turns right
	C=L ; D=H.	Turns left
	C=D.	Quick stop motor
V_{en}=L	C=X ; D=C	Freewheel stop motor
H : high state, L : Low state, X : unimportant		

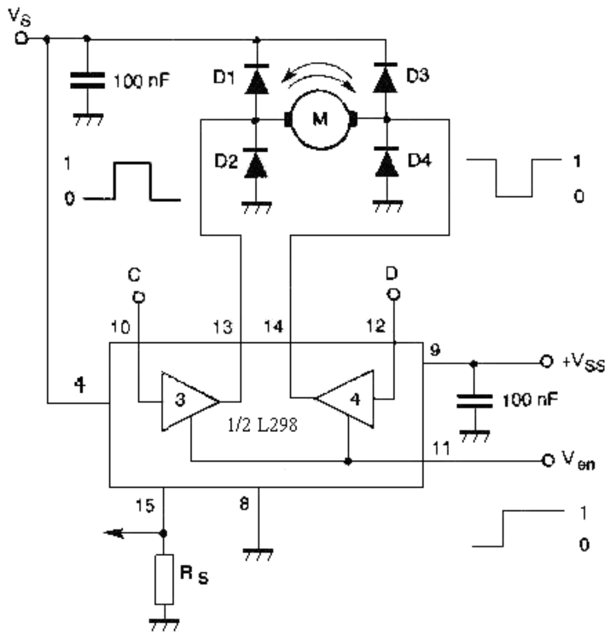

Fig.4 Circuit of DC motor control

C. Detection System of the sun position

For our application we used four LDR sensors, arranged crosswise and optically isolated from each other so that their illumination is the same as if they are pointed at the sun. These four sensors are a glasses system as shown in Fig. 5. This system is secured to the solar panel and placed on the same plane as the latter. Thus, it forms the sensor of sun position detection.

In the case where the solar panel is not pointed at the sun, a signal is generated by the difference in tension from the four LDR. This signal is transmitted to the input of the microcontroller. The PIC16F877A is intended for the adequate control of the motors [7], [9].

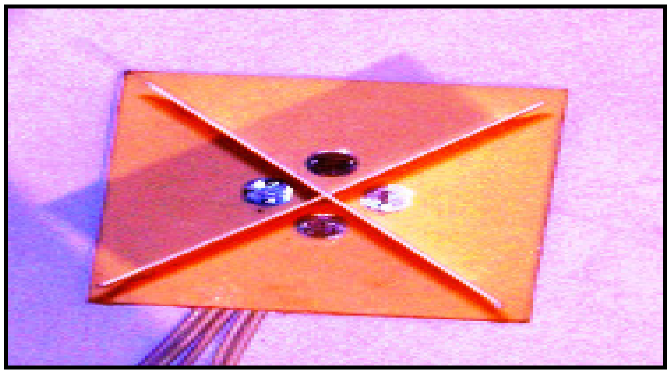
Fig.5 Sunglasses system using four sensors LDR

IV. Realization of Solar Tracker

A. Mechanical realization

We performed a mechanical system able to turn a solar panel with respect to its horizontal axis and in relation to its vertical axis (Fig. 7).

B. Electrical realization

The development of the card requires supply voltages of 5V and 12V (in our project we used a power of a PC). The PIC16F877A microcontroller is in charge of controlling the motors, compare the output voltage of each LDR and receiving the signal of limit sensors. The configuration that allows the microcontroller to manage the above functions is as follows:

- Pin11 and Pin31 are connected to the ground (GND).
- Pin12 and Pin30 are connected to 5V supply (Vss).
- A crystal 20MHZ and two capacitors of 15pF.
- A push button and a resistor of 10kΩ, for the establishment of a control Reset.

The pins A-port and B-port are configured respectively as inputs RA_0 to RA_3 for signal LDRs and RB_0 to RB_3 for end of travel sensors).

To control the motors, we chose the most widely used integrated circuit L298 because it can control two DC motors at the same time and it allows controlling the direction of rotation. The L298N has TTL compatible control lines pin 1 and pin 15, it has a bridge for each (two per integrated circuit).

These connections are used to measure the intensity of the current through the motor windings through the measuring resistors RSA1 RSB1 and 0.5Ω to 3Ω (the adjustment is made to adjust the torque of each motor).

The L298N also has four pin outputs (2, 3, 13 and 14) saw to run two DC motors simultaneously. We add LEDs to indicate the direction of rotation of each motor.

Serial transmission is going to need two terminals, one on the side of PIC16F877A and another on the side of the PC, to receive and send information [7], [8].

To make it compatible RS232 line with the logic level of PIC16F877A was used max232 the integrated circuit. It has a voltage converter which generates a voltage of 10V for 5V through capacitors C1 and C3 (voltage doubler), and generates a voltage of 10V from the voltage of 10V through capacitors C2 and C4. These capacities have the same value of 1µF.

The sensors are installed to indicate the final position of each rotation, two for vertical rotation and two for horizontal rotation.

The LDRs are installed to indicate the movement of the sun, to manage both the horizontal displacement (LDR_2 and LDR_3) and two to manage the vertical displacement (LDR_1 and LDR_4) Fig. 6 [11].

C. Test Bench

Fig.7 Solar tracker realized in the automatic laboratory

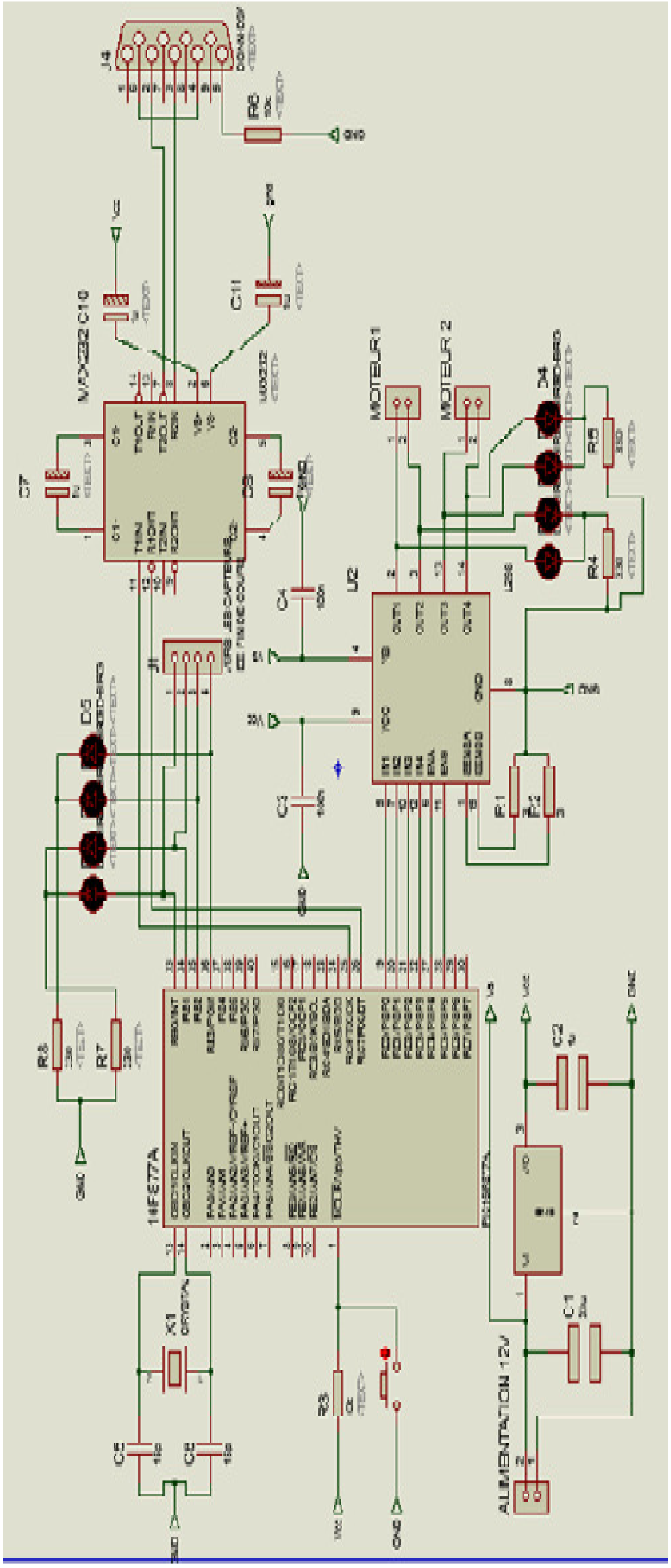

Fig.6 Final Card

V. PROGRAMMING OF THE PIC

Programming the PIC can be done by a machine language (Assembler) or by a high-level language (C, C++, Micro C).

Our program is written in C language with a complete development tool provided by the company for free MICROCHIP and designed specifically for PIC microcontrollers. This tool is called "MicroC".

The programming with C-language requires more rigor and attention to detail.

We must not only know the role of each instruction but also the internal architecture of the microcontroller, addresses special registers, etc.

The tool "MicroC" offers a lot of flexibility to developers, thanks to the many windows that can be opened at any time during a development, which allow you to see the contents of any register.

It allows writing a program to assemble it, simulate before transferring it to flash memory PIC.

The programming language "MicroC" needs access to several files, for this reason, before attempting to write a program, it must go through the following steps:

- First step: creating a project of .c extension, this means defining the project name and the files "MicroC" will be used during development: tracker.c. (Name of our project).
- Second step: editing the source program to be saved as a source file.asm extension: Suiveur1. asm.
- Third step: correction of errors, if the program contains errors, its compilation fails. In this case, it is imperative to return to the extension .asm source file to correct errors.
- Fourth step: compiling the program that is to say, the conversion of source file to file with the same name, but .hex extension, for example: tracker.hex. The message "Build completed successfully" informs us that the build is completed successfully.
- Fifth Step: simulation of the program, which is a kind of virtual checking to see the register contents screen when the instructions are executed.

VI. CONCLUSIONS

This project had the aim to answer the question posed at the outset: "how can we make and use the mobile solar tracking system that rotates a solar panel using adaptive control for controlling the two motors of this system".

Indeed, the project met several fields of study such as electronics for practical design and implementation of electronic circuits and computers for drawing electronic diagrams and simulation of the operation using Proteus. The computer tool was used for programming PIC using Micro C Professional.

On the constraints that have crossed, the realization part was the most delicate phase that requires a lot of patience on the commissioning of the models produced and the time to complete this work.

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