# DESIGN OF A CONTROLLER FOR AN INDUSTRIAL ROBOT ABB IRB 2000

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**Abstract**

It is presented the study of an industrial robot IRB 2000 of the ABB Company. Its mains characteristics of operation, degrees of freedom, etc. they are solved and developed the calculations to obtain the kinematics and dynamics. The accomplished test to each servomotors and the research about its operation. Proposal of different technical of control to the motors.

## I. INTRODUCTION

Robotics is a relatively new field of modern technology that crosses traditional engineering boundaries. Understanding the complexity of robots and their applications requires knowledge of many areas of engineering, computation and mathematics; however in this text is explore the kinematics, dynamics and control of the robot manipulator IRB 2000 is the basic to the understanding of the robot operation.

An official definition of such a robot comes the Robot Institute of America (RIA): robot is a reprogrammable, multifunctional manipulator designed to move material, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks.

In the electronics engineering laboratory of the Instituto Tecnológico Superior De Tantoyuca is found a robot IRB 2000 of the ABB Company which was donated by this, this robot don’t have its controller and was donated for its study, design and construction of the controller, which will be used in the academics practices in the robotics subject.

## II. DESCRIPTION OF THE ROBOT IRB 2000

The basic system consists of:

– mechanical arm;
– control system.

The control system has the whole electronic of the system and allows the external communications with peripheral equipment.

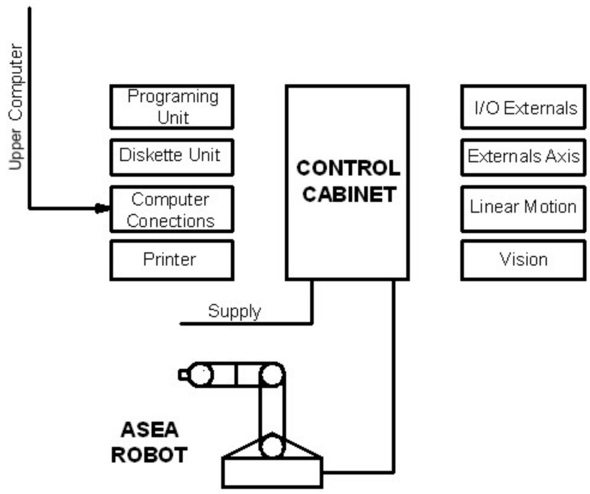


Fig. 1. IRB 2000 system structure

The mechanical robot is provided with servomotors controlled, in each axes, the servo system has:

– speedometer for the speed control;
– resolver for the position control;
– resolver for the absolute measurement system.

Brakes

The robot is equipped with brakes in each axes, is automatically brake in the emergency stops, power supply fails, or when the motors are disconnected of power supply. This brakes setting in stand by mode or totally disconnected. While the robot is running and still static the brakes activate automatically after three seconds (automatic operation) or after five seconds. The brakes can turn off manually one by one through of switches in the side of the robot.

### Motion structure

| Axis | Motion |
|---|---|
| 1 | Rotation of mechanical arm. |
| 2 | Movement toward forward and back of the inferior arm. |
| 3 | Movement upward and down of the arm superior. |
| 4 | Movement of the entire wrist. |
| 5 | Pendulous movement of the wrist with respect to its axis. |
| 6 | Rotation of the coupling plate. |

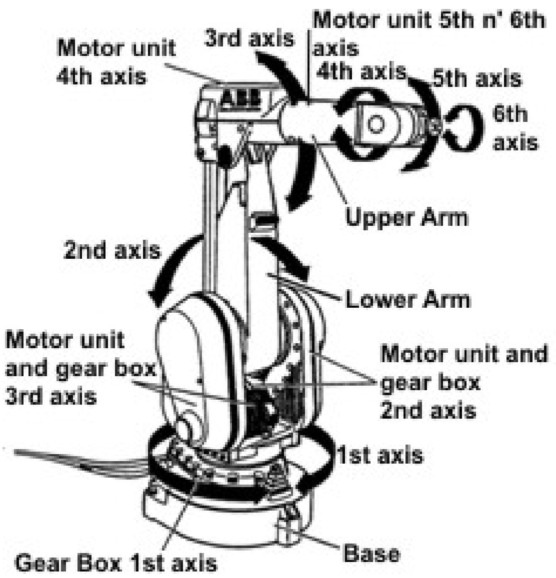


Fig. 2. Motion structure of mechanical arm

### Coordinates system

All the positions of the robot are expressed through the coordinates system that which describe the positions of the robot in the space. This system is setting to the base of the robot with plane X - Y in floor and the axis Z noting upward and concentric to the first rotation shaft.

The path between the positions can be executed in three different coordinate systems: rectangular coordinates, robot coordinates and modified rectangular coordinates. Each one of the coordinate systems will produce a different path and are used according to the needs of speed, precision and direction. All can be activated through instructions in a robot program.

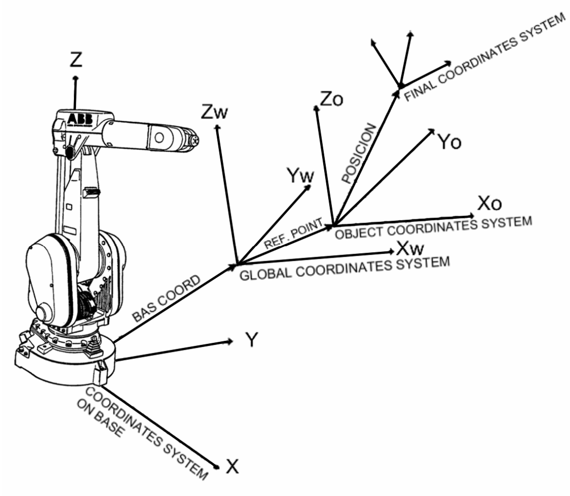


Fig. 3. Coordinate system of robot IRB 2000

For the manual movements have to be three coordinate systems: coordinates system in the base, coordinates system of the tool and the robot coordinates system according to the following graph:

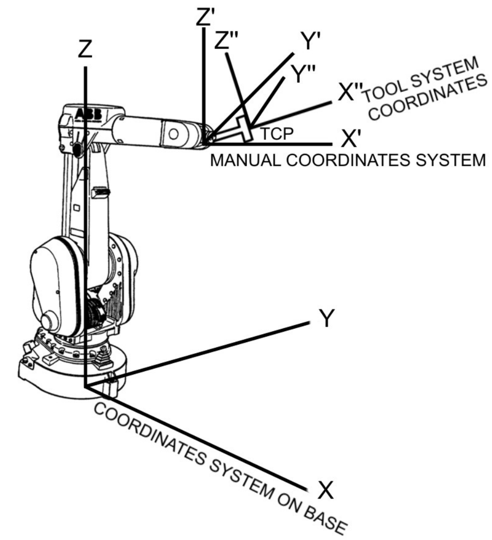


Fig. 4. Articulated configurations

The manual coordinates system is always setting to the assembly bridle of the robot, having the origin in the center of the bridle. The coordinates system of the tool takes its origin in the TCP (tool center point) and is defined respect to the manual coordinates system of the robot, and serves to define objective or final positions of the robot, and in this way the coordinates system of the tool is moved to coincide with the final coordinates system shown in the graph.

The movements and degrees of freedom of the robot IRB 2000 are described in table below.

Scopes of the robot's axis IRB 2000

| Motion | Workspace | Max. Speed, °/sec |
|---|---|---|
| Axis 1: Rotation | +180° – -180° | 115 |
| Axis 2: Arm | +100° – -100° | 115 |
| Axis 3: Arm | +60° – -60° | 115 |
| Axis 4: Wrist | +200° – -200° | 280 |
| Axis 5: Lurching | +120° – -120° | 300 |
| Axis 6: Draft | +200° – -200° | 300 |

IRB 2000 manipulates charges in a wide work area, with great rapidity and precision. This robot is particularly adapted for arc welding, application of adhesives and manipulation of materials, because its speed, wide work area and the inherent flexibility of the design of their 6 shafts. The admissible maximum load is of 10 Kg and depends on the distance to the center on the wrist.

The set of points in the space that they can be reached by the extreme of the wrist of the robot constitute its workspace. Remain limited by the maximum angle or linear displacement that permits the joints and the length of the arms.

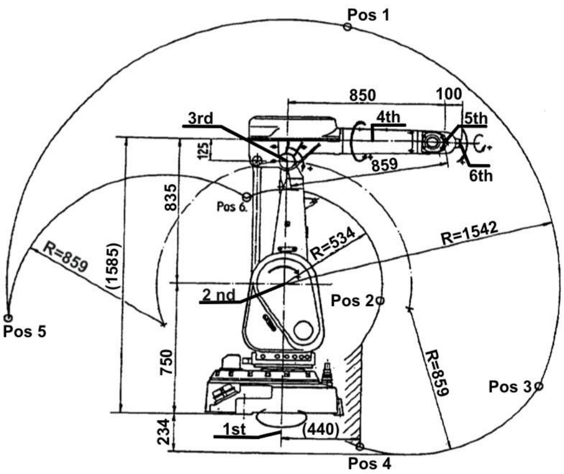


Fig. 5. Workspace of the robot IRB 2000

## III. LABORATORY TESTS

The first stage was consisted of the identification of all the electrical wiring of the robot, the conditions of this, as well as of the servomotors and the brakes, those which were examined feeding them of independent way. Firstly it is carried out the turn off of the brakes applying a direct current voltage of 24 V what permitted to examine the movements of the mechanical arm manually and its workspace upon making this were found problems with the operation of some of the brakes, therefore it was necessary to give them maintenance.

The study and the tests of the servomotors was accomplished applying alternating current voltage of 330 V seeing that at the beginning of the project were thought that the three phase servomotors were of alternating current, this provoked a lacking operation of the servomotors those which presented an excessive warming in short periods of work approximately 1 minute. In these accomplished tests also there were problems for lack of maintenance of the equipment.

Building a control circuit of phase

It was accomplished a circuit of control of phase in order to control the speed of the servomotors with the one which was obtained a control of 90 to 0 degrees.

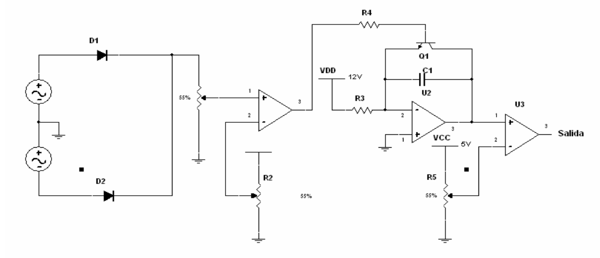


Fig. 6. Circuit of control by phase angle

The proposed circuit counts with three transformers connected in delta – delta to reduce the voltage to 12 VCA, after this signal is rectified and it is compared with a small voltage around the milivolts obtaining thus small pulses in each crossing by zero. Using operational amplifiers in configuration of integrator is obtained a signal saw teeth, furthermore the crossing pulses by zero begin and end at the same time that the signal of the integrator, this permits that this signal will be compared with an equal or smaller voltage to the peak voltage of the signal of the integrator, something which permits to have a pulse width that causes that the triac drives in that time.

This circuit was proved with three focus one for each three phase line as like a mono phase AC motor, the obtained results were satisfactory, not thus for the servomotors particular case of study.

Control by voltage

As following proposed of control for the servomotors is tried reducing the voltage with a transformer, one for each phase.

Upon applying a small voltage to the servomotors these respond with under torque and present little warming, however upon increasing the voltage the torque increases to, as like as the temperature of the servomotors quickly therefore also it was discarded by its lacking operation.

Trip to the Mexico city (ESIME – IPN)

It was accomplished a trip to the Mexico city to the high school of Electrical Mechanical Engineering (Escuela Superior De Ingeniería Mecánica Eléctrica) in search of information about of the robot ++IRB 2000 operation, in this visit was provided the necessary information for the knowledge of the servomotors operation, because could be discovered that the servomotors are not of alternating current but of direct current.

In the ESIME also count with two robots of the ABB industry very similar to which is found in the ITSTA.

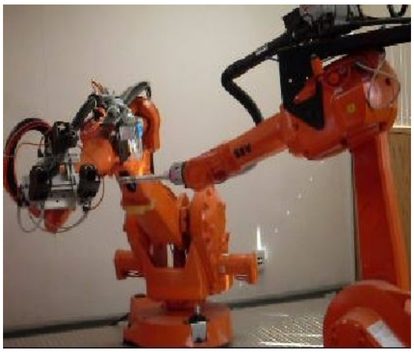

Fig. 7. Robots ABB in the ESIME – IPN

## IV. PROPOSAL OF A CONTROL CIRCUIT DC

There were several control circuit designs for mono phase DC motors as the following:

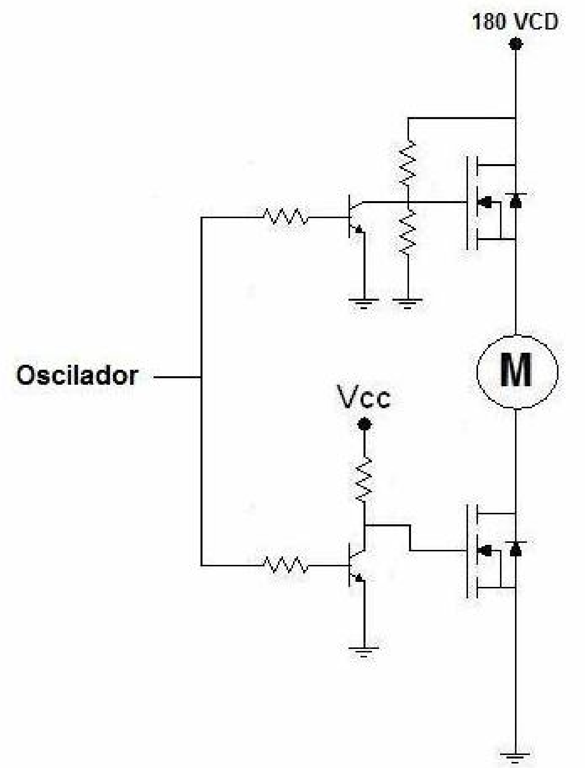


*Fig. 8. Control circuit for a monophasic DC motor*

It is considered a circuit to vary the speed, it is an astable oscillator of 1 to 10 KHz, this frequency is entered a transistor to amplify the signal that enters the Mosfet commuting to the frequency of the oscillator. Upon varying the frequency is possible to vary the speed of the motor.

The circuit show below makes possible the variation of the voltage by means of frequency.

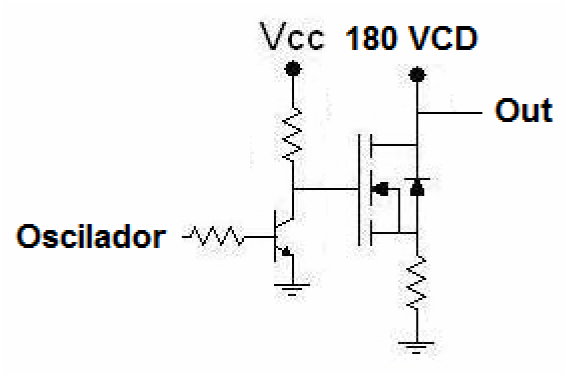


Fig. 9. Circuit to vary the voltage

In the image below is shown the circuit of control for an inductor of a three phase DC motor, firstly, are compared the signals A, B and C to obtain positive and negative pulses. These pulses are entered a transistor to amplify the signals and again to other transistor to induce the necessary voltage to the MOSFET's gate. Once it activated the MOSFET happened through him voltage or ground according to the sequence.

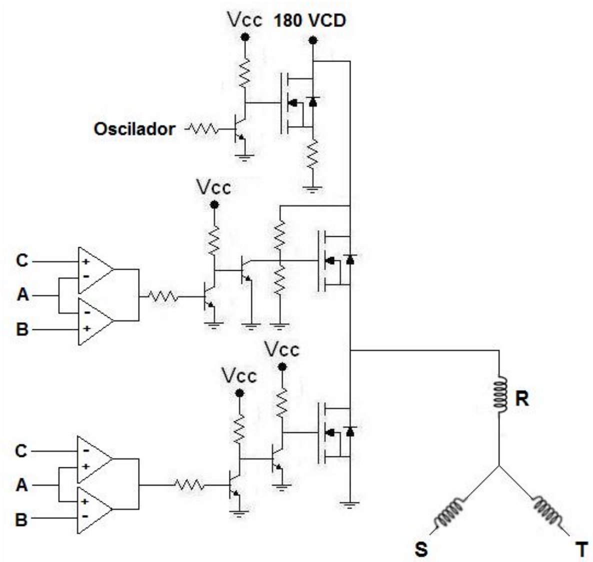


Fig. 10. Control circuit for an inductor of a three phase DC motor

In following table is shown the sequence of each phase of the motor, this sequence is obtained in the window comparator. The first comparator that is shown in the circuit of the image of up, give the pulses show in red and the second comparator give the pulses show in black, these alone pulses are for the sequence that carried the motor.

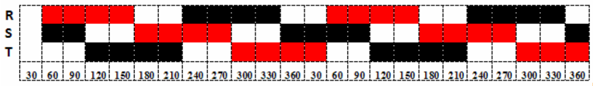


Fig. 11. Sequence for the power supply voltage for the motor

Below it is shown the complete circuit for the speed control of a three phase DC motor, within this circuit we find the circuit of the image 9 that permits us to vary the voltage through frequency, also we find three circuits united as the one which is found in the image 10, these three circuit permits us to induce voltage to each one of the respective inductors (RST).

Also it has six window comparators, counting them of up downward the window comparator 1, 3 and 5 given the pulses labeled in red each one for their RST and the comparators 2, 4 and 6 given the pulses labeled in black also each one for their RST.

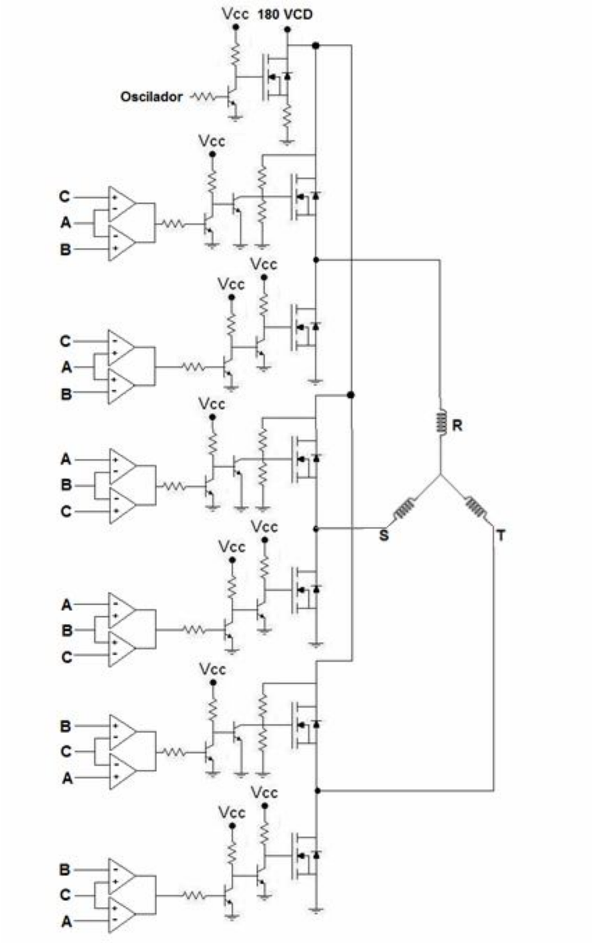


Fig. 12. Complete control circuit

They were studied furthermore the resolvers that accompany to each servomotor, those which are position sensors of the mechanical arm, the obtained results were the waited, two sinusoidal signals synchronized 90°, to take advantage these signals as indicators of continuous position is proposed the design of analog-digital converters with microcontrollers.

## V. PERSPECTIVES TO FUTURE

As first objective is to accomplish the controller to operate the mechanical arm through certain controls in the place; however it is intended to accomplish a PC-Robot interface, the one which permit its manipulation through development software as can be Matlab or Labview, and even be able to operate it in a way remote through internet.

## VI. SUMMARY

This project this yet in development phase, with about 30% of advance, its construction is intended to accomplish through terminal projects in the design of the controlling and even the development of an interface by means of a computer through development environments of applications as it are Matlab or Labview.

## VIII. REFERENCES

[1]. Mark W. Spong, M. Vidysagar, “Robot dynamics and control”

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[3]. Reference Manual, ABB Robotics Products, 1993.

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