PC BASED PARALLEL CONTROL OF ROBOT ARMS

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ABSTRACT

This paper presents the parallel control of robot arms using PC. Parallel control is significant in applications that demand the use of more than a single arm at the same time. We have used two robot arms to demonstrate parallel control and hence, accomplish a final job in minimum time. The robot arms can be made to do any job that demands the use of more than a single human hand. We proposed a control and drive circuit for parallel operation and the control is from a PC, by changing the user input during runtime, it is possible to control the arms in different combinations.

Keywords: Parallel robots, Degree of Freedom, Control Logic, Drive Circuitry

I. INTRODUCTION

Parallel robot control deals with the parallel control of two robots[1]. The robot arms used in our work have 6 Degree of Freedom (DoF) each. We have controlled 3 DoF in each robot arm, both independently and in parallel. Control signals are given to the drive circuitry from a personal computer (PC)[2]. The robot arms can be made to do any task that can be done using human arms. The advantage of parallel control of robot arms is that they can be applied in situations where the application demands the use of more than a single arm to be controlled from a single controller[3]. We have controlled the various manipulators of the robot arms online. Hence quick control of the arm manipulators to the desired position can be achieved. The program was designed to have an interactive menu based selection of arm manipulators during the run time. Arm manipulator motions are reversible and the direction of motion and the duration of motion can be chosen by selecting the appropriate options shown in the menu. The program may also be modified to perform a pre-defined job repetitively as such operations are required in a typical industrial application.

II. OVERALL SCHEMATIC DIAGRAM

The overall schematic diagram of the proposed scheme is shown in Figure 1. The input is given to the PC through the keyboard indicating the arm to be moved and the direction by selecting the option in the menu provided on the screen during runtime. Depending on the option, the control word is generated as output from the parallel port of the PC. The control word is applied to the control logic, which generates suitable signals to activate the corresponding arm manipulators. These signals are then applied to the drive circuitry, which finally rotates the stepper motors in the desired directions. The robots can be made to do jobs that require more than one human hand for their operation.

III. CONTROL LOGIC BLOCK

The block diagram of the control logic is shown in Figure 2. The control word from the PC is of 8 bits width. The first 4 bits give the sequence for the stepper motor to rotate in clockwise / anticlockwise directions. The next 4 bits are used to select the arm manipulators of the robots. These 4 bits are taken as two separate pair of 2 bits each in order to allow the parallel operation of two selected arm manipulators. Each of the 2 bit pair for arm manipulator selection is given to a demultiplexer and 1 of the 8 outputs of the demux gets activated depending on the input bits. This selected output is used to activate the corresponding stepper motor to cause the motion of the arm manipulator. The 1st 4 bits from the parallel port are given to a Darlington pair ULN2003A. The next 2 bits are given as inputs 1 and 2 to the demux 74138. The mode bits are set in such in a way that the output pins 15,14,13 become low when the input bits are 00,01,10 respectively. Each output bit is inverted and given as one of the input to the AND gates of three 7408s. The other input to the AND gates of each 7408 comes from the 4 outputs of the ULN2003A. Hence, depending on the arm manipulator selection bit, one of the 7408s will be active at a time and the sequence will be applied to the drive circuitry of that arm manipulator. Thus depending on the inputs to the 74138 only one of the three 7408 is selected i.e., one of the input to the chosen 7408 will be turned on. The other input to all the AND gates is of course the sequence that is required to rotate the motor. Hence the output for all the AND gates other than the selected AND gate will be off or 0V.

IV. DRIVE CIRCUITRY BLOCK

The block diagram of the drive circuitry is shown in Figure 3.The drive circuitry block consists of power transistors TIP42C to drive the stepper motor. The output of the control logic is fed to the base of a power transistor through a resistor. The excitation voltage for the stepper motor is applied to the emitter. The stepper motor coils are connected in sequence to the collectors. Whenever a pulse appears at the base of the transistor, that particular transistor will conduct; the emitter and collector will be short circuited causing the excitation voltage to be applied to the stepper motor coil. Thus the stepper motor is excited. The order of excitation of the colored coils of the stepper motor determines the direction in which the motor moves. This causes the arm manipulator to move in a bi-directional way. The base can be made to move in left/right direction; the elbow can be made to move in up/down direction and the gripper can be made to open/close. The speed of action or the speed of motion of the robot arm manipulators can be controlled via the software by increasing or decreasing the delay that has to occur between two consecutive pulses. A higher ampere rating voltage supply is required here to excite the stepper motor. The current rating of the source used was 5A.

The combined circuit diagram of the control logic and drive circuit for both the robot arms is shown in Figure 4.

V. ALGORITHM OF THE CONTROL PROGRAM USED

The flow chart of the sequence of control action from the PC is shown in Figure 5. The algorithm steps of the program used are given below.

1. Display the menu with various choices on the keys to press and the corresponding arm manipulator that will be selected.
2. Wait until the user presses a key.
3. Depending upon the key pressed go to one of the following steps from 4 to 8.
4. If the key pressed is ‘1’, then the control word corresponding to the selection of 1st robot arm manipulator has to be made. For this reason the first pair of two bits used for arm selection is made 00 and the second pair is made 11.Then the sequence for the motor motion is given in the first 4 bits for a single time.
5. If the key pressed is ‘2’, then the control word corresponding to the selection of 2nd robot arm manipulator has to be made. For this reason the first pair of two bits used for arm selection is made 01 and the second pair is made 11.Then the sequence for the motor motion is given in the first 4 bits for a single time.
6. If the key pressed is ‘3’, then the control word corresponding to the selection of 3rd robot arm manipulator has to be made. For this reason the first pair of two bits used for arm selection is made 11 and the second pair is made 00.Then the sequence for the motor motion is given in the first 4 bits for a single time.
7. If the key pressed is ‘4’, then the control word corresponding to the selection of 4th robot arm manipulator has to be made. For this reason the first pair of two bits used for arm selection is made 11 and the second pair is made 01.Then the sequence for the motor motion is given in the first 4 bits for a single time.

8. Similar instructions are written for the individual control of all the arm manipulators.

9. If the key pressed is 'F1', then the control word corresponding to the selection of 1st robot arm manipulator and 4th robot arm manipulator has to be made in parallel. For this reason the first pair of two bits used for arm selection is made 00 and the second pair is made 00.Then the sequence for the motor motion is given in the first 4 bits for a single time.

10. Similar instructions are written for the parallel combination of any two arm manipulators.

11. Wait for the user to give the next instruction.

12. If the key pressed is Esc then quit the program otherwise go to step 3.

VI. EXPERIMENTAL SETUP

The experimental setup is shown in Figure 6. It consists of the two robot arms placed in position, a PC to control the manipulator motion of the robot arm(s) and the control logic and drive circuitry to accomplish the final motion of the robot arm manipulators to do a task. The control adopted here is a feed forward control i.e., there is no control signal that comes from the robot arms to the computer. The flow of control signals is only from the computer to the robot arms.

VII. EXPERIMENTAL RESULTS AND DISCUSSION

The robot arm1's elbow and base were moved to reach the robot arm2's gripper, which holds a pen with a cap fitted in the far end. Then the gripper of the robot arm1 was opened and positioned near the cap of the pen .The pen's cap was then gripped and taken apart from the pen. At the same time the base of robot arm2 moves to get the next pen using its base, elbow and gripper. We were successfully able to control the desired arm manipulators in parallel using above algorithm. The photographs of the different robot arm positions during the experiment are shown in Figure 7.

VIII. CONCLUSION

We were able to demonstrate parallel operation of the robot arm manipulators by controlling e different DoFs of different robot arms simultaneously using a single controller. It must be noted that the parallel control will be very useful in reducing the time involved to complete a job that involves two or more manipulators. In the Biomedical field, parallel control will become inevitable for futuristic robotic surgeries, as they require two or more robot arms working synchronously.

REFERENCES

1) Rex Maus, Randall Allsup, Robotics: A Manager's guide, John Wiley and Sons (1986).

2) Robert J Schilling, Fundamentals of robotics: Analysis and control, Prentice Hall of India (1996).

3) Peter B Scott, The Robotics Revolution, The Complete Guide, Basil Blackwell (1986).

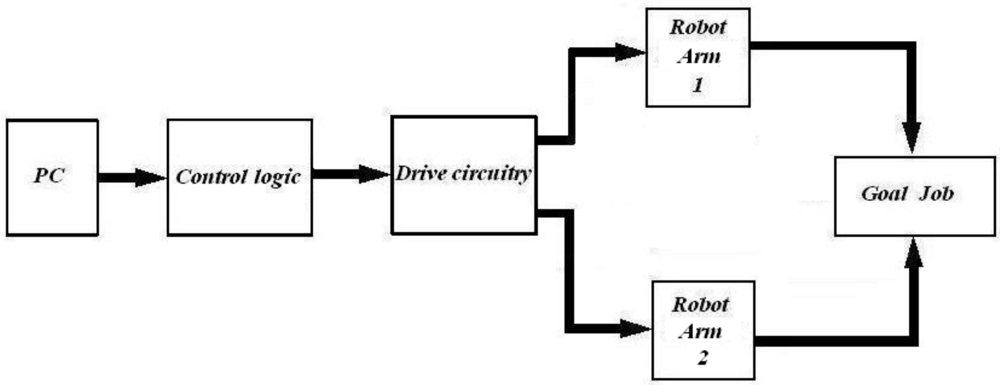

Figure. 1: Overall Schematic Diagram

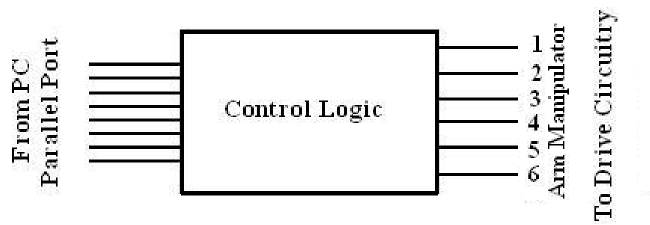

Figure. 2: Control Logic Block Diagram

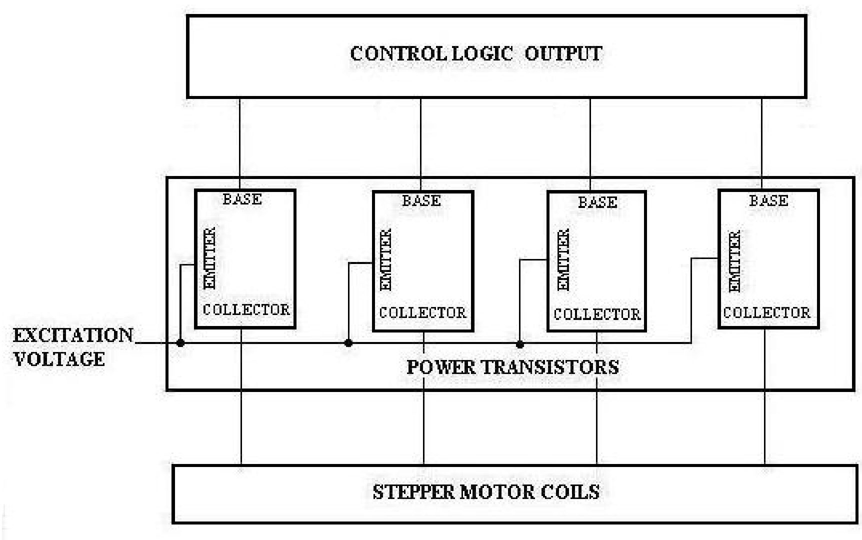

Figure. 3: Drive Circuit Block Diagram

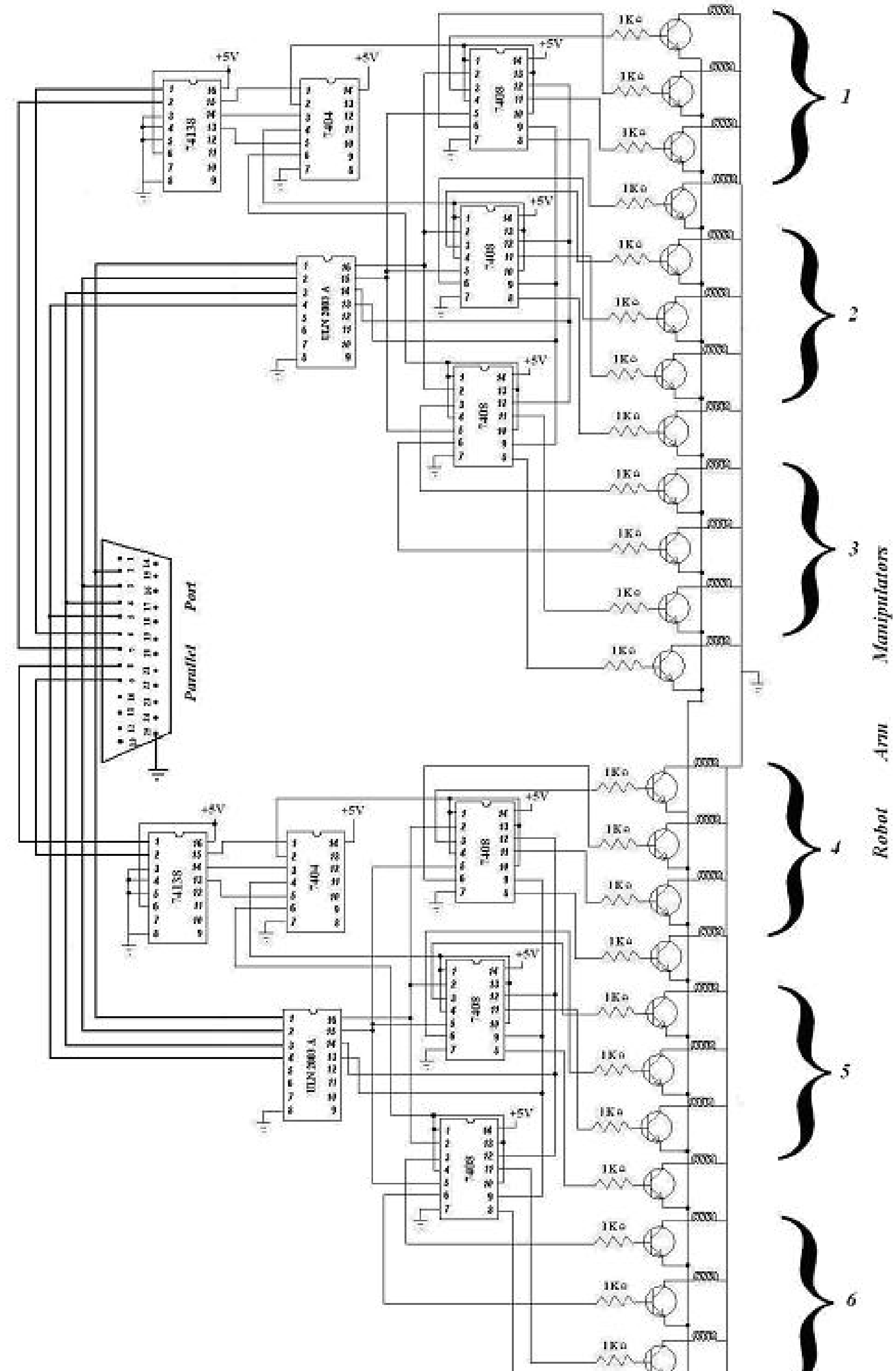

Figure. 4: Complete Circuit For Parallel Control

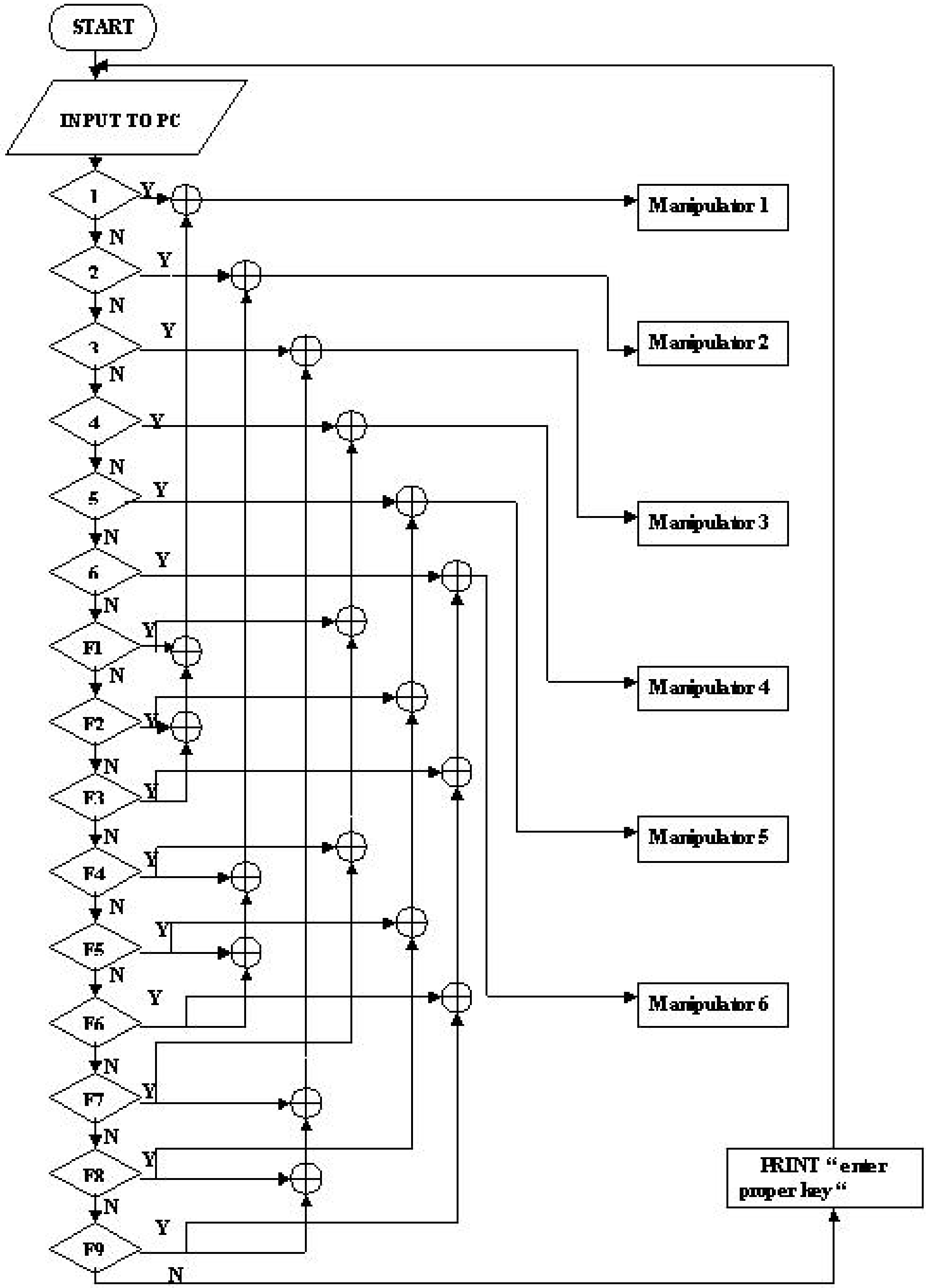

Figure. 5: Flow Chart For The Control From PC

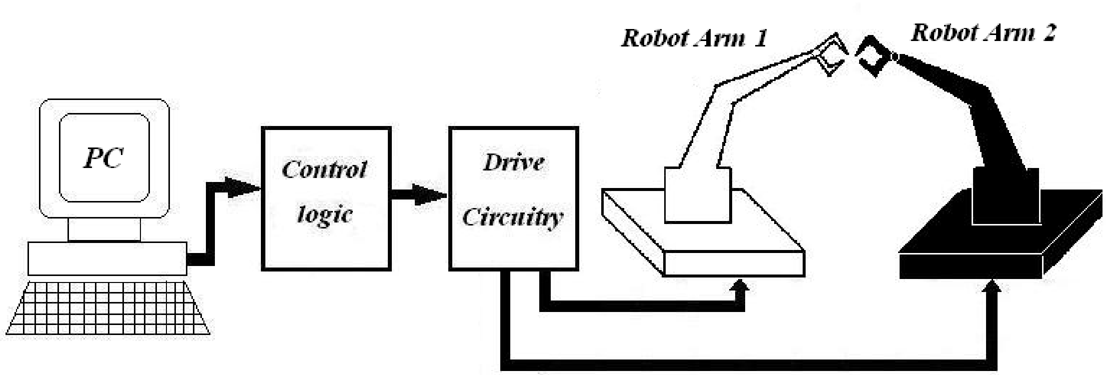

Figure. 6: Schematic Representation Of The Experimental Setup

Figure. 7: Photographs of the different robot arm positions during the experiment

(a) Initial position of the Robots

(b) Robot 1 grasping the pen from Robot 2

(c) Robot 1 taking the pen to a different position

(d) Robot 1 putting the pen into a container held by Robot 3