Hydraulic Robot Arm Controlled by Human Arm

PharandeAmitkumar R[1],ShindeRohit P[2], ShedgeSuraj S[3],Aldar D. S.[4],
KarmaveerBhauraoPatil College of Engineering and Polytechnic,Satara, Maharashtra, India
E-mail:{[1]vikypharande@gmail.com,[2]shinderohit585@gmail.com, [3]suraj110592@gmail.com, [4]dilip_aldar@rediffmail.com}

***Abstract*—** The hydraulic robotic arm majorly consists of two parts. One is the human arm movement sensing and transmitting section and other is Hydraulic and Robot Arm structure. The Hydraulic Robot Arm system consists of simplified robotic arm structure similar to the human arm and the hydraulic structure to control the movement of robotic arm. The linear carbon potentiometers based sensing mechanism is used to sense the human arm actions.

The human arm actions are transmitted wirelessly using the RF transmitter- receiver to make the system more efficient. The simple and innovative hydraulic control section is designed using the solenoid valves and the pump to perform the different actions of the robot arm. The robotic arm provides the similar actions which are performed by the human arm.

Keywords—Sensors, Robotic arm, human arm, Microcontroller, RF transmitter, and RF receiver, solenoid valve, cyllinders.

I. INTRODUCTION

Think if you can control the humanoid robot which can follow your action in the distant field,isn't that an innovation? And here we have achieved this concept in our project. We got an idea from the movies Avatar and The Pacific Rim. These movies inspired us to think in the different aspects of robotics. Then we decided to make it happen in real. The robots are controlled through wired connections between the robot end and the control end. The wired connectivity of the robot is not suiatble for the application of walking robot which can serve the different task in inductry. For exampe the human robot is picking the object and carrying it from one place to another. Therfore the wired human robot can not serve the purpose in the different direction of the walking while carrying the load/object. The wireless robotic control is the best solution to carry the different activity in the industrial applications where the path of the human robot is random. For such applications the power requirement might be very large and the hydraulic offer the flexibility for this situation. The hydraulic is best solution for the heavy duty works. It is also observed that there is no precise control on the hydraulic therfore we decided to give the electronics control to hydraulic section. Thus to get heavy duty work done by hydraulic systems as per human wish in remote places the hydraulic robot arm is developed.

Presently there are different sensors such as the pressure or force sensors used for the human arm movement detection. These sensors are expensive and are rarely available in the local electronics market. Such sensor detects the pressure applied on it which is very difficult for sensing the smaller movements of human arm. It is necessary to provide the simple solution for the sensing mechanism. The hydraulic power pack is much expensive and the complex for the controlling the actions of the hydraulic cylinders. Also for using the motors there are additional requirement of gearing mechanism to generate the holding torque for holding the robot action.

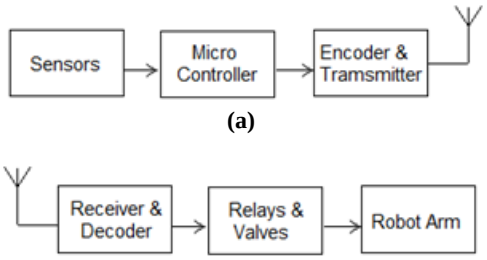

Figure 1 a) Human Arm Sensing, Controlling and Transmission unit b) RF Receiver, Hydraulic control and Robot Arm

Figure 1 show the major two parts of the hydraulic controlled robotic arm. The sensing mechanism is designed using the linear carbon potentiometer in order to make the mechanism simple and economical instead of using the pressure or force sensor. The hydraulic section is designed using the solenoid valves, hydraulic pump and relays.

Rest of the paper is organized as follows, section II gives the proposed solutions for the hydraulic robot system . Section III discusses the implementation of the system including the software and hardware implementation. Section IV describes the results and the discussion. Finally the paper is concluded in section V.

II. HYDRAULIC ROBOT ARM WITH SENSING MECHANISM AND CONTROLLING

As shown in the Figure 2 the hydraulic robot arm system is divided into two sections such as sensing and control unit and the hydraulic robot arm system. In the sensing and control unit the four linear carbon potentiometers are used as movement sensors. The accurate sensing of the human arm movement is crucial part and is achieved by simple design of the sensing mechanism as shown in Figure 2(a). The sensing data is applied to the microcontroller CC430, which generates the controlling signals for the different action of the arm. The control signals form the microcontroller is applied to the parallel to serial

converter to make compatible to RF module. Before transmitting the signal through antenna it is amplified using amplifier designed to enhance the signal strength.

Figure 2(b) show the hydraulic robotic arm section. The received signal is applied RF module and then to the decoder to know the controlling actions. The decoder outputs are feed to the relays to perform the on/off actions of the hydraulic pump, and solenoid valves. The solenoid valves are then connected to the cylinders for the different movements of the robotic arm.

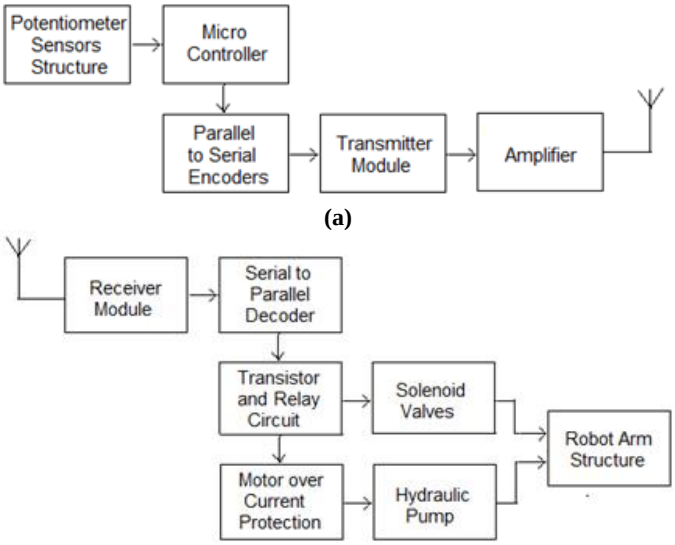

Figure 2 a) Human Arm Movement sensing and Control, b) RF receiver, Hydraulic control and Robotic Arm

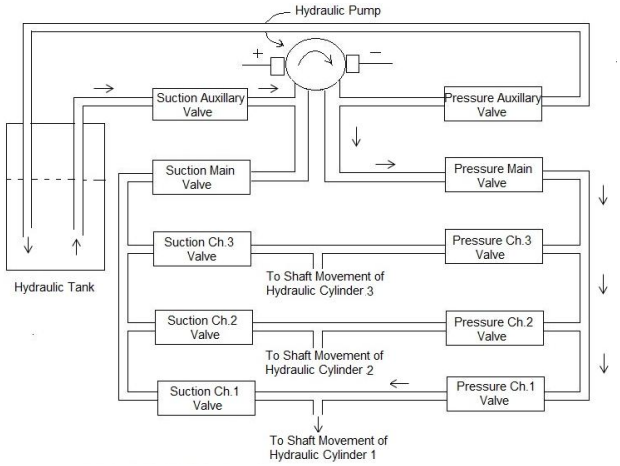

Figure 3 Hydraulic solenoid structures for the robotic arm control

The best solution and alternative to the hydraulic power pack is developed using the relays, solenoid valves and hydraulic pump. The innovative hydraulic solenoid structure is designed and is shown in the Figure 3. The functionality of the channel 1 is shown by arrows in the Figure 3.

III IMPLEMENTATION

A. Hardware Implementation

The Figure 4 shows the human arm sensing and transmitting section. The four potentiometers are used for the detection of different movements of human arm such as fingers, elbow and shoulder. The 3.6 volt constant power supply is provided to the potentiometer circuit from the base board. The wooden structure of the human arm is made to sense the various movements by varying it with the human arm. The shafts of the potentiometers are fixed in between the joints of the wooden arm structure. This structure is made to fit with the human arm by using the wrist belt. When the human arm moves in either direction, the respective shaft of the potentiometer rotates in the same direction and the voltage drop across that pot gets changed. The changing voltage is as input to the microcontroller MSP430F6137R4 and programmed based on the sensed voltages and the output signals are generated. The Code Composer Studio version 5.5.0 is used to program the microcontroller. These output signals are then converted into serial bit stream using three HT12E the 4 bit encoders. The 4:1 multiplexer is used to select either of the encoder output. The transmitter modulates this serial data with the 433 MHz carrier signal and transmits it by using the antenna.

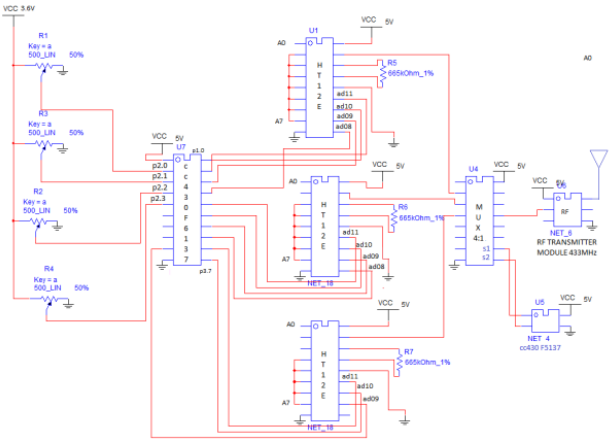

Figure 4 Human arm sensing and transmitting section

The Figure 5 shows the receiver and hydraulic section. It consists of the hydraulic robotic arm structure, the hydraulic control structure and RF receiver. The robotic arm structure is made by wood. There are three hydraulic cylinders for different movements of fingers, elbow and shoulder. The A434 receiver module is used to receive and demodulate the signal. This signal is decoded by using three HT12D 4 bit decoders. This signal is given to the base of transistor BC547 to turn the relay on and off. These relays are connected to respective solenoid valves and hydraulic pump. The robotic arm movement is achieved by opening or closing the respective solenoid valves. The outputs of solenoid valves are connected to the hydraulic cylinders. These hydraulic cylinders are used to control the movement of robotic arm.

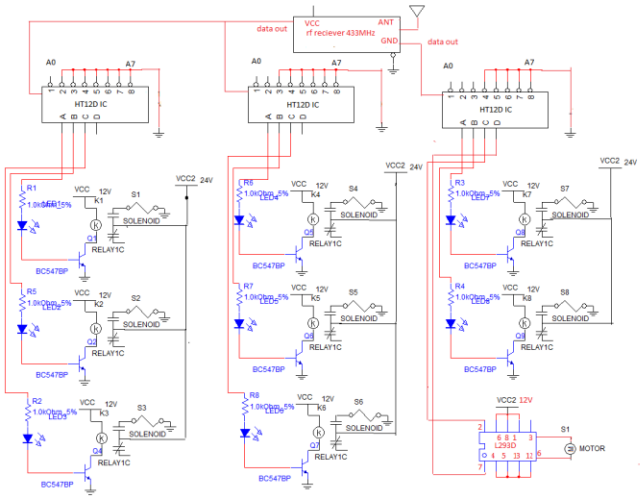

Figure 5 Receiver and the hydraulic section

At the output side the relay structure and solenoid valves are used to control the movements of robotic arm. The transistor circuit is used to trigger the relays. The 12 volt supply voltage is given to relay and 24 volt is connected to common terminal. When the signal is applied to base of transistor it will turn on and respective relay will be triggered. And the common voltage will get applied to output terminal of relay at which solenoid valve is connected. These valves are used to control the direction of flow of the fluid and in the sense to control the movement of shaft of the cylinder. There are total 10 solenoid valves to control the movement of shaft of 3 different hydraulic cylinders. These solenoid valves are classified as pressure valves for 3 channels and suction valves for same 3 channels. And remaining valves are used as main and auxiliary valves. When the pressure main valve is on the auxiliary valve for suction is on simultaneously and vice versa. By opening and closing the solenoid valves the pressure and suction can be applied to hydraulic cylinders. These cylinders are connected to robotic arm structure made up of wood. According to shaft movement of respective cylinder the robotic arm action is achieved. The total 8 relays are used to turn on or off the solenoid valves.

B. Software Implementation

This section discusses the software implementations of the hydraulic robot arm. The program is developed for the controlling actions performed by the human arm. Figure 6 a) and Figure 6 b) show the flowchart for the developed algorithms and program. The variable voltages are generated by using potentiometers when the action is performed by human arm. These variable analog voltages are applied to the analog to digital converter of the CC430F6137R4 controller. The controller is programmed to give the digital output values for changing input analog voltages. The code for the controller is developed by using the Code Composer Studio version 5.5.0 that uses cross C compiler. According to variable analog input voltages the digital outputs are stored into the different memory locations. After varying the same analog input we get the new digital output value. Further this new value is compared with the previous value stored in the memory location. According to the result of comparison (the result may be greater than, less than or equal to) the output signal is generated.

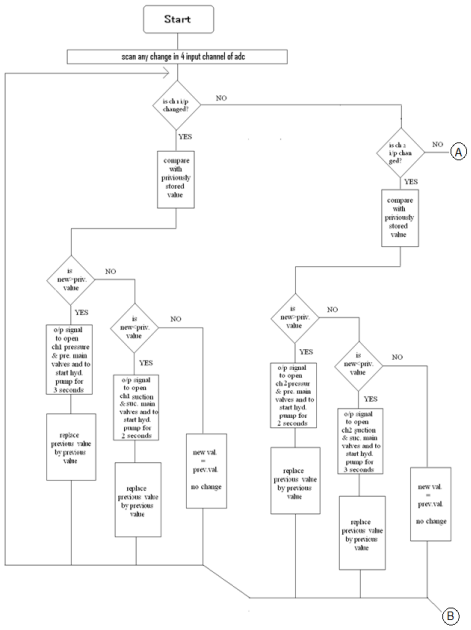

Figure 6 a) Flow Chart for Sensing and Controlling

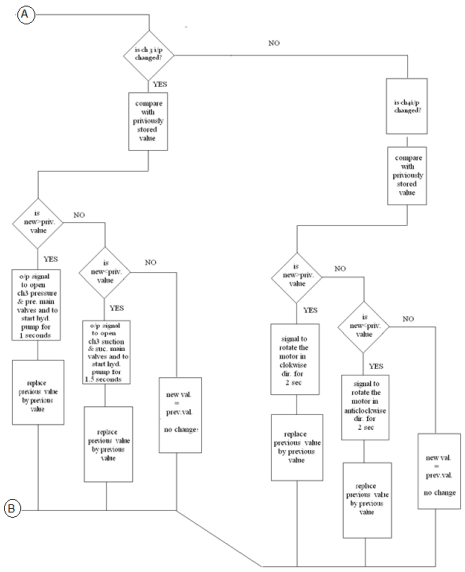

Figure 6 b) Flow Chart for Sensing and Controlling

For example, if we consider the channel number 1 and if potentiometer is not varied the values in the memory will be same (old and new output value) and the equal to condition will be satisfied in the comparison result, thus there will be no any action. Now, if we move our arm along with potentiometric sensor the value of that potentiometer will be changed, thus new digital output will be greater than previous value stored in the

memory location and the comparison result will be greater than, thus the output signal is generated to open the pressure valve of channel 1 by driving the relay connected to the valve. This signal is transmitted along with other signals (such as hydraulic pump on). At the receiver side this signal is decoded and respective action of the robotic arm is achieved.

IV. RESULTS AND DISCUSSION

This section presents the results at every section of the complete system in order to analyze the performance of the system. The complete robot arm controlled by human arm is shown in Figure7. For the sensing and control side, sensing structure is fitted with human arm. As per the movement of human arm the sensor structure is moved. According to arm movement the voltage drops across respective potentiometer gets changed. The status of analog input port pins of the controller gets changed. As per changing analog voltage the result of analog to digital converter is changed which is stored into a memory location of controller. Further changes in the human arm gives new digital value through analog to digital converter and gets compare with previous value stored in the memory location of controller. According to the comparison result output signals are generated and previous value get replaced with new value. For example, consider channel no.1 if human arm is at rest position then no any changes occurs in the sensor circuit hence stored value in the memory location remains same. If human arm move in the upward direction by 10 degrees the voltage drop get changes by 130mV. This analog voltage is converted into the digital value and compared with previous stored value. According to the result greater than condition is satisfied and the signal is generated to open the pressure valve of channel no.1 for 200ms and the pressure main valve and hydraulic pump for the same time this parallel port pin output is converted in serial and transmit by using encoder.

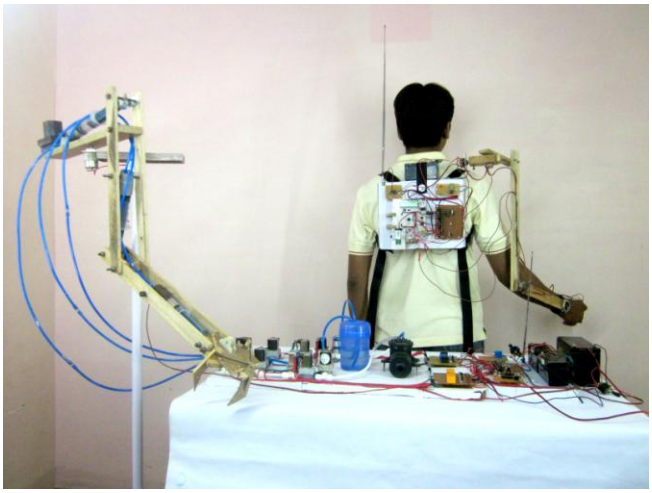

Figure 7 Hydraulic robot controlled by human arm

Transmitter module: at the hydraulic robot arm side which is situated about 20meters away from transmitting end and the data is received serially. This is decoded in parallel and this parallel data given to the relay structure. In the relay structure the receive signal bit is given to base of the transistor to drive a relay. When status of the received signal is 1, the transistor is switched on and relay gets on, thus the common terminal voltage is transferred to solenoid valves and it gets open as mention in the above example. The data is received and the relay for channel 1 pressure, main pressure and motor is switch on. Accordingly the pressure channel 1 valve along with the main pressure valve and the hydraulic pump remain on for 200ms. Thus the robotic arm will move approximately by 10 degree in the upward direction. In this way for all movements of human arm with sensor structure the hydraulic robot arm follows the approximate movements.

V. CONCLUSIONS

The hydraulic robotic arm controlled by human are tested and it is observed that, as the human arm moved in either direction the robotic arm follows the same movements. This is applicable for all the subparts of the arm i.e. shoulder, elbow and finger.
The sensing of the human arm actions are achieved perfectly for the applications like the pick and place. The wireless connectivity to check the remote utility of the robotic arm is also designed and developed. The Innovative section is design to provide the economical and efficient solution for the power efficient industrial application. The utility could be improved by using the video camera and feedback for the motoring and intelligent actions performed by the robotic arm.

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REFERENCES

[1] H. Kazarooni, "Human Robot Interaction via the Transfer of Power and Information Signals" Systems, Man and Cybernetics, IEEE Transaction, vol. 20, no. 2, mar/apr 1990.

[2] Fanping Bu, "Nonlinear Model Based Coordinated Adaptive Robust Control of Electro-Hydraulic Robotic Arms via over parametrizing method", Robotics and Automation, IEEE International Conference on, vol. 4, 2001

[3] A. S. Fukunaga, A. B. Kahng, F. Meng, "Cooperative Mobile Robotics: Anticedents and Directions", Intelegent Robots and Systems, Human Robot Interaction and Cooperative Robot Proceding 1995, RSJ/IEEE International Conference on, vol. 1, 1995

[4] R. Y. Tsai, R K. Lenz, "A New Technique for Fully Atonomous and Efficient 3D Robotics Hand/Eye Callibration", Robotics and Automation, IEEE Transactions on, vol. 5, no. 3,June 1989

APPENDIX A – BILL OF MATERIALS

The table I give the details of the expenditure of components and material used.

Table I the detail bills of the component and material used.

	Component	Manufacturer	Cost per component	Quantity	Total cost of component	TI Supplied/ Purchased
1	**CC430F6137R4**	**TI**	**-**	**1**	**-**	**TI Supplied**
2	**CC430F5137**	**TI**	**-**	**1**	**-**	**TI Supplied**
3	**Code Composer5.0 (software)**	**TI**	**-**	**-**	**-**	**TI Supplied**
4	**L293D**	**TI**	**-**	**1**	**-**	**TI Supploed**
5	**UA741**	**TI**	**-**	**1**	**-**	**TI Supplied**
6	**Potentiometer**	**-**	**10**	**4**	**40**	**-**
7	**Transmitter & Reciever 443MHz**	**-**	**400**	**1**	**400**	**-**
8	**HT12E**	**-**	**60**	**3**	**180**	**-**
9	**HT12D**	**-**	**60**	**3**	**180**	**-**
10	**Relay**		**20**	**9**	**180**	**-**
11	**Solenoid valve**	**-**	**350**	**10**	**3500**	**-**
12	**Hydraulic Pump**	**-**	**1500**	**1**	**1500**	**-**
13	**Hydraylic cylinder**	**-**	**40**	**3**	**120**	**-**
	Total Cost of the Project				**Rs. 4750**	