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CONSTRUCTION OF ELECTRIC HYDRAULIC JACK USING CONTROL SYSTEM

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ABSTRACT

An electric Hydraulic Jack Using control system has been constructed. It's an electromechanical device that requires less effort to operate. The pumping is done by attaching the lever to a slider-crank arrangement mechanism that is driven by a direct current (D.C) electric motor to perform lifting action instead of the manual handheld method which requires more energy. The jack can be powered by a 12V supply usually from the car battery and controlled by a single multi-purpose key remote control. The Jack was tested using difference vehicles such as Toyota Camry, Honda accord, Peugeot 406. Results shows that the jack is working efficiently.

KEYWORDS: remote control, Microcontroller, control system, stepper motor, relays

INTRODUCTION

The bottle hydraulic jack is used for lifting cars off the ground to change the wheel or perform any form of maintenance or repair under the car. In the jack mechanism the motion of the pump piston is fixed along the smaller cylinder. This arrangement is widely used in machines such as air compressors, planers and vulcanizing machines as reported in Lu, (2008), Yan, (2009), Martin, (1989) and Liu (1987).

The integration of electronic devices for the operation of mechanical systems is often termed mechatronics which required the combination of mechanics, electronics, sensors, actuators and controls as discussed in Shelty and Kolk, (1997). Some attempts are made to design automatic control systems for actuating mechanical systems.

Nagchandhuri, (2010) investigated the redesigning of mechatronic system for the operation of slider-crank mechanism.

A feasibility study for controlling the motion of slider-crank mechanism with appropriate sensing and automation is elaborated. Pous e t.al., (2008) analyzed the actuator as a bios pored mechatronics system through analogies between mechatronics and biological actuating mechanisms that include hierarchical control of actuators, switch control of power flow and some transduction principle.

Mechatronics are used in automatically controlled products and devices, such as automobile engine control systems, remote controls, office equipment, appliances and power tools.

Microcontroller makes it economical to electronically control many processes, Bates, (2004), Roy Niladri, (2006).

The design of the slider crank mechanism for pumping operation of the jack and the crank rocker mechanism for actuating the release valve has been reported in an earlier paper, Raji et. al., (2009). Figure 1 show the automated assembled system.

The entire automatic hydraulic jack operation consists of the following;

1. The pump mechanism coupled to the hydraulic jack lever link.
2. The valve mechanism which operates the hydraulic jack release valve.
3. A D.C stepper motor which operates the valve mechanism.
4. A D.C wiper motor which operates the pump mechanism.
5. The remote control system unit which sends signals to the prime movers.

This paper discusses the design of the control system unit for the automation of the hydraulic jack. the control system consists of the microcontroller, the relays which acts as the I/O devices, and various circuitries required for achieving the functions of the control system.

The design has three relays to control the d.c. motors. The three relays required to perform the operation on the mechanism processed signals from the microcontroller unit which takes the control commands from a user via a remote control system which uses the radio frequency signal.

FEATURE OF THE CONTROL SYSTEM

The electrical control section is divided into three core parts namely the display, the input,and electrical circuit board. the electrical circuit board consists of several units like the power unit, voltage regulator, microprocessor unit, oscillator unit e.t.c

Microcontroller

The AT89C51 microcontroller and prototype board are the key component for the control. It provides the interface between the operator and mechanism. It takes in operator input via the remote control unit and sends out signals that control the stepper motors. The unit consists of the oscillator circuit and the set and reset circuitry. The entire program that controls the input and display unit is written into it. The following procedure is used to program the microcontroller
1. The program is written using an assembly language and typed in a text editor.
2. The program is compiled to generate the object file Count.obj
3. The object file is linked to create the executable file Count.omf
4. A hex file, Count.hex is created and used to burn the program into the AT89C59 chip.
5. The burning process involved the connection of special computer accessory called programmer into the USB port of the computer where the program was written.

There are three I/O units used in this communication. These are all shared as a serial Bus between the microcontroller and the three relays. The set of rules for the communication are as discussed in frank, (1996).

Oscillation Circuit

The oscillation circuit is used to generate clock pulse used for the timing of the microcontroller operation. The circuit shown in figure 2 made used of the quartz crystal oscillator chip and two mica capacitors each capacitance is of 30pF. The MP49GC crystal oscillation with frequency of 6MHz frequency rating is employed.

Reset Circuitry

The reset circuitry is used to ensure that the microcontroller start its operation from the beginning each time the power is turned on. The circuit as shown in figure 3 consists of 22uf capacitor in parallel with a 1k resistor linked to the microprocessor through pin 9.

Input unit Design

The input unit is made up of the remote control (RC) and the receiver circuit as shown in figures 4a and 4b. The remote control consists of a multi-purpose button that sends signal to the microcontroller. The RC system is pressed once to start the operation, a radio frequency signal is sent to the microcontroller which interprets the signal and activates one of the three relays to lock the valve mechanism via the stepper motor. The operation is controlled by a second relay action which actuates the wiper motor for the operation of the slider-crank mechanism for the lift operation. A second press of the button activates the third relay to cut off control of the lift operation. A continuous depression of the button for a period of about five seconds reactivates the first relay to reverse the valve mechanism.

A manual switch is also provided for the system in case the remote control fails.

One of the terminals of the switch is grounded as shown in figure 5 while the other is connected to the power supply (Vcc) via a 10K pull up resistor.

Power Supply
The power source is a 12 volt battery. The battery is used to power the two D.C. motors. The 12 volts is regulated to 5 volts with LM805 voltage regulator type for the operation of the microcontroller and the relays. The stepper motor required at least 12 volts D.C to power the mechanism. This could not be supplied by the microcontroller so it was connected to the 12 volts D.C. source.

Motor Sizing
The control torque requirement for the motor is developed using proportional plus integral plus derivative (PID) control scheme as determined in Nagchaudhuri, (2002).
$r=Q + K_pE + K_vE + K_1 \{ Edtr$ (1)
Where K_p, K_v, K_1, are the proportional, derivative and integral gains respectively, Q_d is the desired acceleration of the crank . E and E are the angular position and velocity errors of the crank respectively.

RESULT AND DISCUSSION
The various parts of the Hydraulic jack has been coupled and assembled together, and it was ensured that all the component parts were firmly and properly connected, the device was tested as follows:
The two wire terminals of the project was connected to the terminals of a 12 volts car battery ensuring that the positive cable was connected to the positive terminal and negative cable to negative terminal, thus ensuring that the circuit is protected from damage. The jack was positioned under a Toyota Camry Honda accord & Peugeot 406 as load to be lifted up. To ensure that the load is not concentrated at a point, a plank, which helps to spread the load, was placed between the jack and the body of the car.
As soon as the wires are connected the red light will shows indicating that current is flowing through the circuit. The green light which comes on as the remote control was pressed shows that the jacking action has started. As soon as the required height has been reached, the button was pressed again to stop the lifting action. To lower the car, the same button was pressed continuously for 5 seconds, to release the pressure built up in the jack gradually, the process is repeated unit the jack has been relieved completely the lowering of the car by the weight or force of the car on the jack.
The manual buttons for the operation of the jack up and drop down, in case of the failure of the remote control system was also tested.

CONCLUSION AND RECOMMENDATION
The Jack was constructed using locally available materials and skills .The device was tested using difference vehicles. The Jack was found to work effectively on Peugeot 504, 505, Volkswagen Golf and Honda accord. The jack raised the cars successfully. The jack would not work for any car whose maximum height from the ground is not above 218mm, the remote control was tested to control the device efficiently at a maximum distance of 600mm. The circuit could however be improved in future work to increase the distance of the remote control from the jack.
The device is recommended for use in several sectors especially at automobile companies and industrial applications where the control of hydraulics used to lift objects is done from a remote distance.

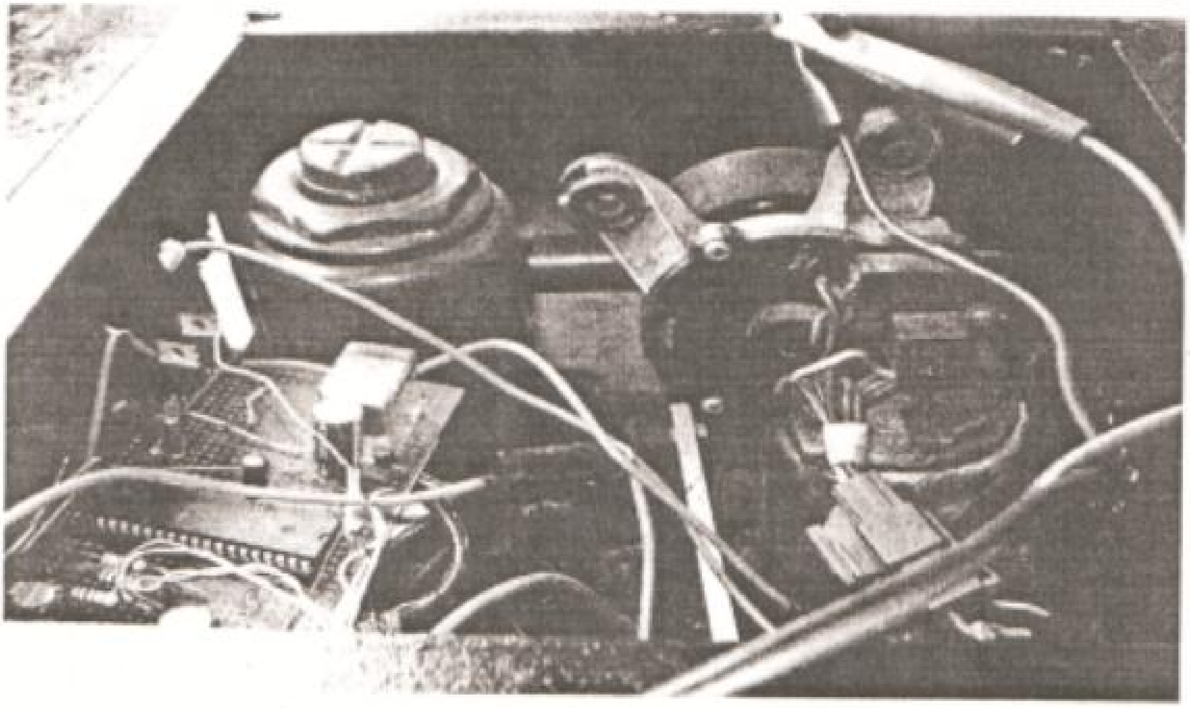

Figure 1: The Automated Hydraulic Jack Assembly

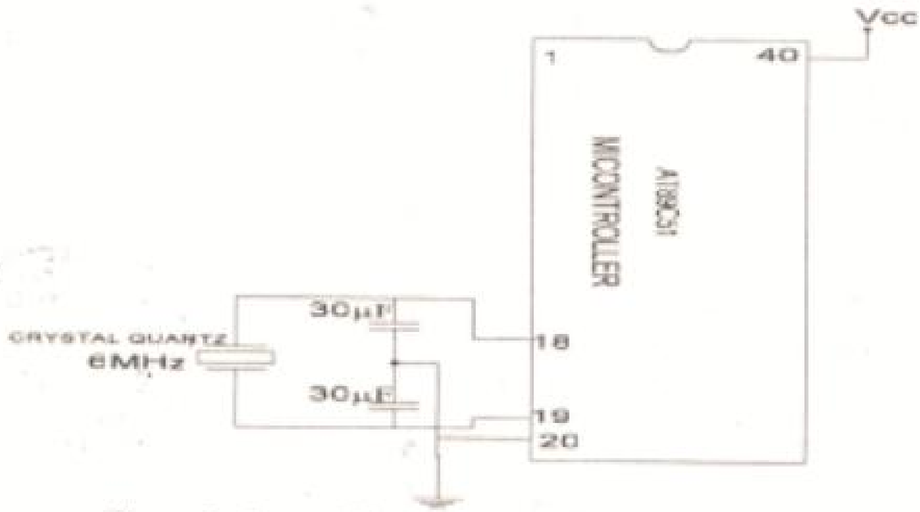

Figure 2: Crystal Oscillator Interfacing the Microcontroller

20

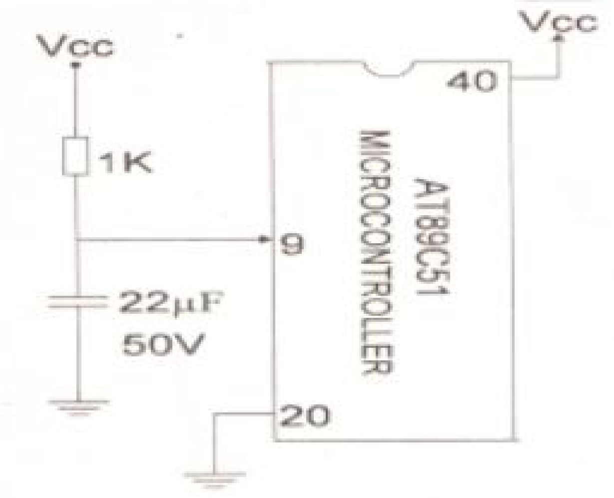

Figure 3: Reset Circuitry

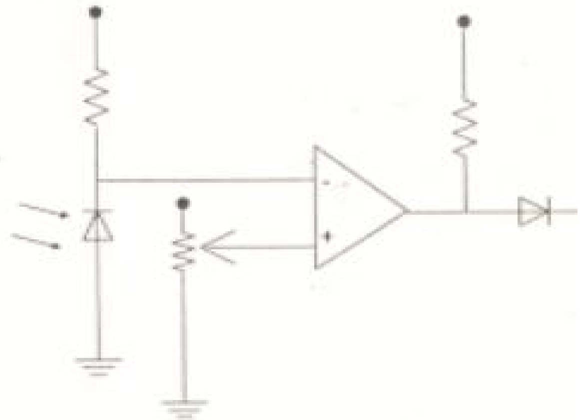

Figure 4a: The Receiver Circuit

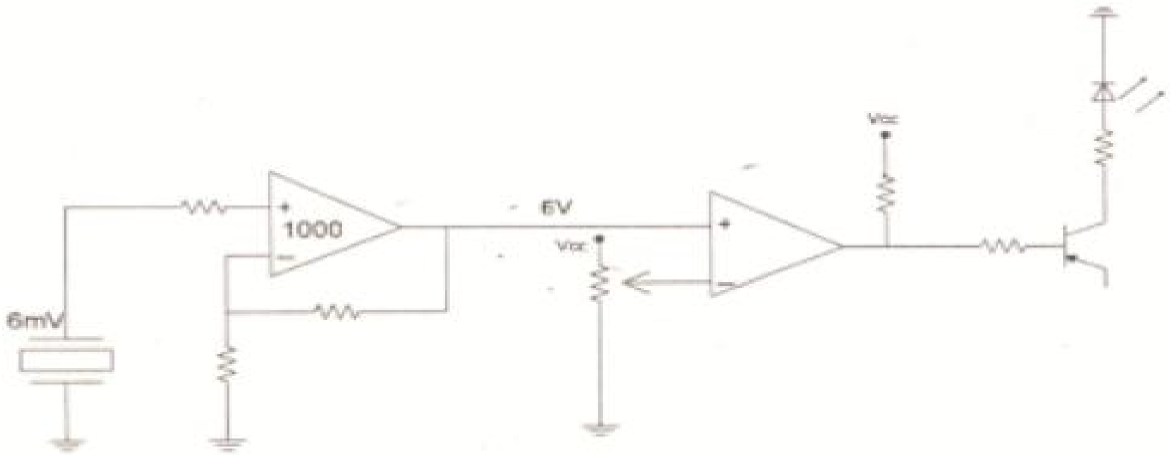

Figure 4b: The Remote Control Circuit

21

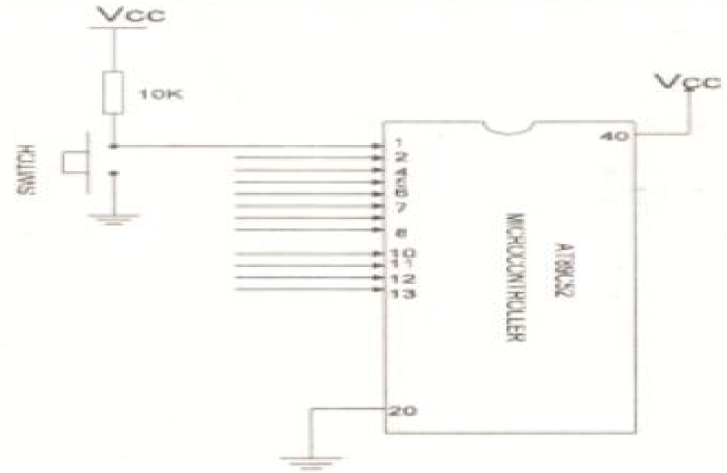

Figure 5: Illustration of Input Switch Connection to the Microcontroller

22

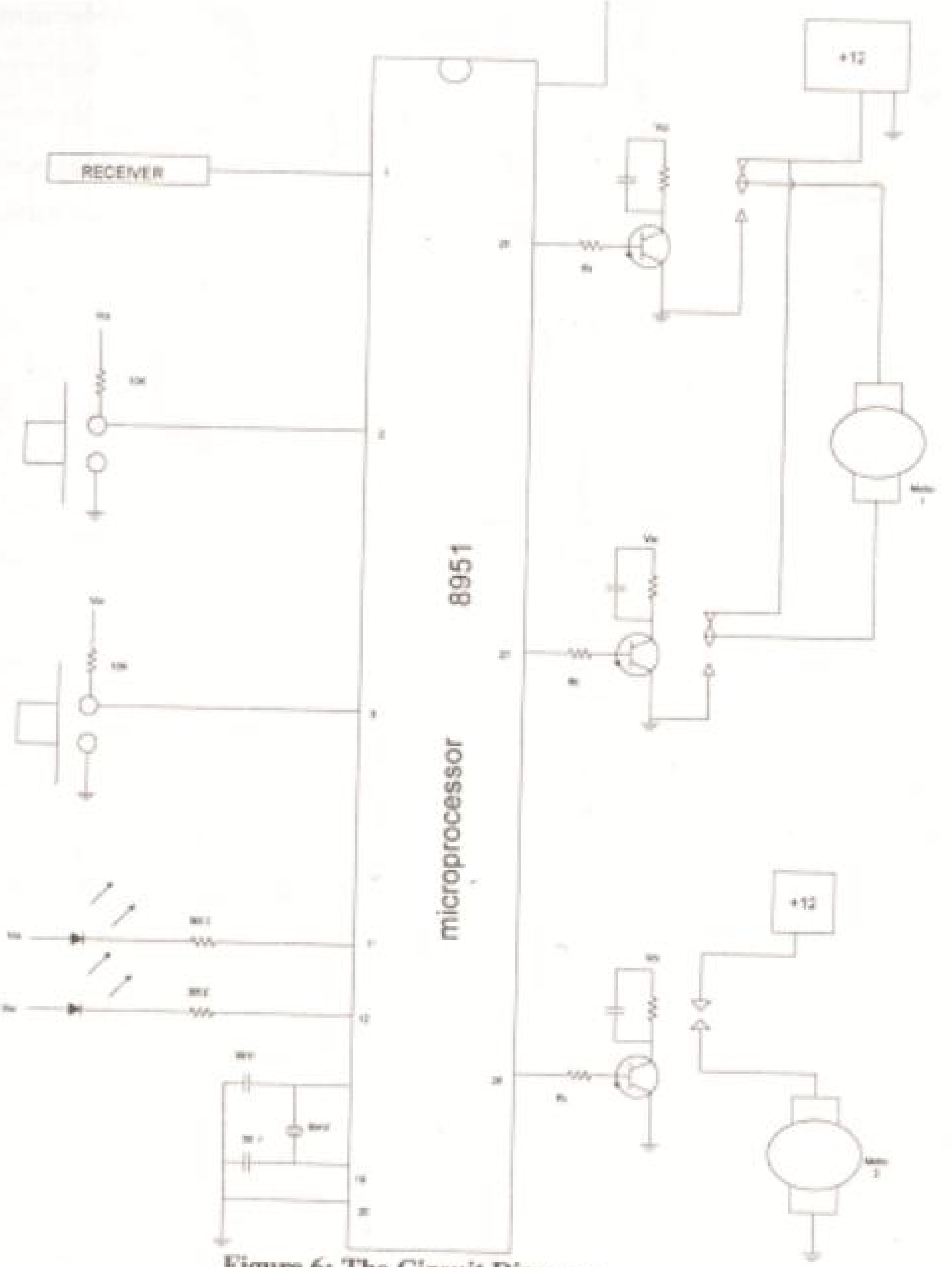

Figure 6: The Circuit Diagram

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