Design and Implementation of a Remote Controlled Car Jack

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ABSTRACT

This paper would involve designing the system and also constructing a unit that can be used to jack up any regular car as controlled by the transmitter to the receiver. The receiver circuit would be controlled by microcontroller. It also involves the designing an infra-red transmitter circuit capable of transmitting a coded frequency. The receiver circuit would be able to receive the transmitted infra-red beam and be able to process and decode the control signals for the upward movement of the jack. The control mechanism consisting of the dc motor and the link mechanism would be arranged such that it will allow for smooth control and well fabricated and attached to the hydraulic jack. The complete unit should be able to raise up loads placed on it.

Keywords: Interface, Microcontroller, Multivibrator, Screw jack, Transmitter.

INTRODUCTION

There has been tremendous advancement and improvement all over the world practically due to science and technology.

Technology can be said to be an art of applying sciences to develop equipment and services to ease any of man's numerous problems. This work is an example of using technology to ease up the former way of car jacking. The car jack is a very important device all vehicle owners must have to help in servicing their car when the need arises. The need for the car jack is often necessitated by flat tires that need repair or replacement. Other cases include repairs that will require going under the vehicle and so to get access to such areas, the car jack is needed.

The type of the car jack used will determine the amount of physical labor to operate them to raise the car to the required height and most times result in much exertion from the individuals and could be energy sapping. The objective of this work is to include electronic control with necessary mechanisms that will make the job of jacking cars for maintenance easier and friendly. The system will control the upward movement of the car jack through a remote control. This will help to conserve energy and save time. The jack is controlled downwards by manually adjusting the valve for downward movement control of the jack. The work would involve designing the system and also constructing a unit that can be used to jack up any regular car as controlled by the transmitter to the receiver. The receiver circuit would be controlled by microcontroller. Tests would be

conducted after construction. The system would be designed using locally sourced materials from the market.

A car jack is a mechanical device that allows drivers and mechanics to get underneath a car, usually to change a tire, oil or some car part like brakes. There are two kinds of car jacks: hydraulic and screw types. Most car jacks that are included with cars are screw types. Of the screw-type mechanisms, there are scissor jacks, common in newer cars, and bumper jacks, common in older cars.

The jack is usually found in the trunk of the car with the spare tire. Both the scissor jack and the bumper jack use an arm to allow the car owner to lift the car. The lug nuts must be loosened if the car is jacked or raised up when changing tires. The scissor jack is designed to turn the screw with the arm in a clockwise motion to raise the platform that the car rests on (or notch that fits into a hard point on the car's undercarriage). As you turn the handle, a large screw pushes the platform up by shortening the distance between end points; the mechanism crawls along the grooves of the screw so as to lift the car with relatively little effort.

The jack is placed on a flat, concrete surface and one must ensure no one is sitting in the car. There is a lot of weight supported by the jack. The car descends by reversing the process: turn the screw counterclockwise, making sure to tighten the lug nuts after the car's tire has minimal weight on the surface, and then lowering the jack the rest of the way [1].

- ❖ A screw jack is commonly used with cars but is also used in many other ways, including industrial machinery and even airplanes. They can be short, tall, fat, or thin depending on the amount of pressure they will be under and the space that they need to fit into. The jack is made out of various types of metal, but the screw itself is generally made out of lead.
- ❖ Hydraulic and Foot Operated: The hydraulic jack is common in car shops and garages. It uses hydraulic fluid to push the jack head up and lift the car. The hydraulic fluid is pumped into the jack head which extends the arm of the jack either by turning a crank that raises the bar or by pushing up the bar itself. Other types of jacks include lifts operated by foot pedals. When you press the foot pedal, a small crank turns and slowly lifts the jack. It ratchets into place on every step, and then the operator can reset and depress the jack pedal again to lift the car another few inches.

Block Diagram of The Proposed Remote Control Car Jack

The operational principle of the remote control car jack is explained with block diagram shown in figure 1.0. It shows the basic building block of the control system.

Figure 1.0 Block diagram of the remote control car jack

Remote Control Transmitter

This block refers to the transmitter stage of the system. The function of this stage is to transmit a low frequency pulse to the receiver stage to control upward movement of the jack. It consists of two oscillator circuits that generate two different frequencies; one is the modulator and the other the carrier. The control communication means is the infra-red link [2], [3].

Receiver and Driver Interface

This stage consists of the infra-red receiver stage that picks up the transmitted infra-red beam and converts it to electrical signals, simplifies and shapes the signal to pulses and then decodes the frequency to switch power to jack for upward movement. This stage also consists of the jack mechanism motor driver interface that helps connect the control circuit to the jack mechanism [2,3].

Jack Control Motor Mechanism

This stage consists of the mechanism that controls the car jack. This mechanism consists of the dc motor and the gear and link mechanism for transmission of movement from the motor to the

jack. This link mechanism function is to convert the rotary movement to linear movement [2].

Car Jack

The car jack of choice is the hydraulic car jack because it is the type that requires less force for its operation.

DESIGN ANALYSIS OF THE REMOTE CONTROL CAR JACK

Design Specification

The design of the remote control car jack is presented with the calculations and analysis of component values, specifications and principle of operations. The individual stages design and their operational principle is hereby presented. The design consists of the following stages;

- ❖ Power Supply stage
- ❖ Infra-red transmitter stage
- ❖ Infra-red receiver stage
- ❖ Microcontroller stage
- ❖ Jack mechanism driver

Power Supply

The circuit needs a power supply of +5V for the control circuit. The power source of the circuit is from the car battery which 12V dc. Figure 2 shows the power supply diagram. R_L is a current limiting resistance for the regulator. The circuit will need up to 300mA for its operation from the voltage regulator. Capacitor C1 was connected for decoupling of noise signals and its chosen value is 0.1 μ F.

To obtain the regulated +5V a voltage regulator of 7805 was used in the design to get the voltage. The specification is as shown [4].

7805 Voltage Regulator;

Maximum input voltage = 35V

Output voltage = 5V

Drop out voltage = 2V

Minimum input voltage = 7V

Output current = 1A

For Supply voltage $V_{cc} = 12V$

Regulator voltage = 5V

Load current $I_a = 0.3A$

$R_L = (V_{cc} - V_{reg}) / I_a = (12 - 5) / 0.3 = 23.3\Omega$

Choose 22 Ω as the closest and available resistor standard.

The transmitter circuit was powered by a 9V dry cell battery.

Figure 2: Power Supply Circuit

Design of The Infra-Red Transmitter

The circuit consists of two 555 timer astable multivibrator and an infra-red LED driver serving as the transmitter. One astable multivibrator (IC₂) function is to generate pulses with a

frequency of 38 kHz. This choice of 38 kHz is based on the infra-red receiver module that operates on a 38 kHz carrier. The second mutivibrator (IC₁) is used to generate a low frequency pulses to control the upward movement of the jack. The modulated infra-red beam is directed towards the direction of the infra-red receiver of the car jack mechanism [3], [5].

The circuit of the astable multivibrator (IC₁) for the low frequency is presented in figure 3 below

The expression for frequency of oscillation is

$$F = \frac{1.44}{(R_A + 2R_B) C_1} \quad \text{Choosing } R_B = R_2 = 10\text{k}\Omega$$

$$C_1 = 1\mu\text{f}$$

$$F = 68 \text{ Hz}$$

$$R_A = R_1 = \frac{((1.44 / (F C_1)) - 2R_B)}{1}$$

$$= \frac{((1.44 / (68 \times 1 \times 10^{-6})) - 20000)}{1}$$

$$R_A = R_1 = 1176 \Omega$$

A resistor value of 1.2k Ω was chosen as the closest value.

Applying equation 1, for the carrier frequency generation using

IC2 Choosing $R_B = R_4 = 18\text{k}\Omega$

$$C_2 = 1\text{nf}$$

$$F = 38 \text{ kHz}$$

$$R_A = R_4 = \frac{((1.44 / (F C_1)) - 2R_B)}{1}$$

$$= \frac{((1.44 / (38 \times 10^3 \times 1 \times 10^{-9})) - 36 \times 10^3)}{1}$$

$$R_A = R_3 \approx 1.8 \text{ k}\Omega$$

The infra-red LED TIL131 has the following specifications;

Forward voltage drop $V_d = 3\text{V}$

Forward current $I_c = 15\text{mA}$

LED current $I_c = 15\text{mA}$

Limiting resistance $R_7 = (V_{cc} - V_d) / I_c = (9 - 3) / 15 \times 10^{-3}$

$$R_7 = 400\Omega$$

Transistor Tr₁ amplifies the signal from the pulse generator. An NPN transistor 2SC945 was used in the design.

Figure 3: Infra-red Transmitter circuit

C945 NPN (silicon) Specification

$$BV_{CEO} = 40\text{V}$$

$$BV_{CBO} = 70\text{V}$$

$$I_c(\text{max}) = 0.6\text{A}$$

$$Pd(\text{watts}) = 0.625\text{W}$$

$$Hfe = 100 \text{ typical}$$

$$V_{ce}(\text{sat}) = 0.2\text{V}$$

For a collector current of 15mA;

$$I_c = 15\text{mA}$$

$$\text{Base current } I_b = I_c / \beta = 15 \times 10^{-3} / 100 = 150\mu\text{A}$$

For effective base drive the base current was increased by a factor of 10.

$$\text{Base resistance } R_6 = (V_{cc} - V_{be}) / I_b = (9 - 0.7) / 150 \times 10^{-5} = 5533.6 \Omega$$

Choose 5.6 k Ω the closest and available resistor standard.

Infra-Red Receiver

The infra-red receiver circuit adopted for this circuit was borne out of the need for reliability. This was implemented using infra-red receiver module specially designed for infra-red reception of 38 kHz signals. It consists of the infra-red receiver

photo-diode, filter and amplification circuits and demodulator inbuilt inside it and the diagram is in figure 4.

The infra-red circuit uses the infra-red receiver module IRX-TSOP1738 model for the infra-red detector circuit. The TSOP17xx – series are miniaturized receivers for infrared remote control systems. PIN diode and preamplifier are assembled on lead frame, the epoxy package is designed as IR filter. The demodulated output signal can directly be decoded by a microprocessor. TSOP17xx is the standard IR remote control receiver series, supporting all major transmission codes. [6,7].

It has the following features;

- _ Photo detector and preamplifier in one package
- _ Internal filter for PCM frequency
- _ Improved shielding against electrical field disturbance
- _ TTL and CMOS compatibility
- _ Output active low
- _ Low power consumption
- _ High immunity against ambient light
- _ Continuous data transmission possible (up to 2400 bps)

Operating frequency is 38 kHz and supply voltage of 5V.

The module was used for 38 kHz signal detection to control

the jack mechanism.

Resistor R_8 is for current limiting as specified in the datasheet and the specified value;

$$R_8 = 100\Omega$$

Transistor TR_2 amplifies the signal from the infra-red receiver module.

Collector current $I_c = \beta I_b = 1.2\text{mA}$

$$I_b = I_c / \beta$$

$$I_b = 1.2 \times 10^{-3} / 100 = 1.2 \times 10^{-5} \text{ A}$$

$$R_{10} = (V_{cc} - V_{ce}) / I_c = (5 - 0.2) / 1.2 \times 10^{-3} = 4000 \Omega \approx 3.9\text{k} \Omega$$

$$R_9 = (V_{cc} - V_{IR} - V_{be}) / 1.2 \times 10^{-5}$$

Where V_{IR} is the output from the infra-red receiver module;

$V_{IR} = 3\text{V}$ (datasheet)

$$R_9 = (5 - 3 - 0.7) / 1.2 \times 10^{-5} \approx 10\text{k} \Omega$$

$$R_{11} = 10\text{k} \Omega$$

Capacitor C_3 was added to reduce noise signals across the infra-red receiver module, and its chosen value is $10\mu\text{F}$ (specified).

TR_2 is a PNP, 2SA733 transistor, with following data;

2SA733 PNP (silicon) Specification

$BV_{CEO} = 40\text{V}$

$BVC_{BO} = 70\text{V}$

$I_{c(\text{max})} = 0.5\text{A}$

$P_d(\text{watts}) = 0.6\text{W}$

$H_{fe} = 100$ typical

$V_{ce(\text{sat})} = 0.2\text{V}$

Figure 5: Infra-red Receiver

PIC16F84A Microcontroller Circuit

The microcontroller used in this work is the Microchip PIC16F84A.

It has Only 35 single word instructions to learn and all instructions single-cycle except for program branches which are two-cycle.

The features of the microcontroller are as listed below [8,9,10];

❖ Operating speed: DC - 20 MHz clock input

❖ 1024 words of program memory

❖ 68 bytes of Data RAM, 64 bytes of Data EEPROM

❖ 14-bit wide instruction words, 8-bit wide data bytes

❖ Direct, indirect and relative addressing modes

❖ Four interrupt sources:

- External $RB0/INT$ pin, - TMR0 timer overflow

- $PORTB<7:4>$ interrupt-on-change, - Data EEPROM write complete

Peripheral Features:

❖ 13 I/O pins with individual direction control

❖ High current sink/source for direct LED drive

o 25 mA sink max. Per pin, - 25 mA source max. Per pin

❖ TMR0: 8-bit timer/counter with 8-bit Programmable prescaler

❖ Watchdog Timer (WDT) with its own On-Chip RC Oscillator for reliable operation

❖ Wide operating voltage range:

o Commercial: 2.0V to 5.5V

o Industrial: 2.0V to 5.5V

❖ Low power consumption:

- < 2 mA typical @ 5V, 4 MHz

- 15 mA typical @ 2V, 32 kHz

- < 0.5 mA typical standby current @ 2V

Below is the pin layout of the PIC16F84A microcontroller

Figure 6: Pin layout of the PIC16F84A microcontroller

Figure 7: Microcontroller Circuit

Pin 15 and pin 16 are for oscillator. The oscillator of choice because of its stability is the crystal oscillator and the chosen one is the 4.0 MHz because of its availability. Pin 4 is the master clear terminal and it is used here for start up delay to protect the program from timing problem at start caused by power up surge. Resistor R and Capacitance C, determine the delay time.

For a start up time delay $T_s = 330\mu s$ and $C_1 = 100nF$, thus
 $R_1 = T_s / 0.7C_s = 330 \times 10^{-6} / 0.7 \times 100 \times 10^{-9}$
 $R_1 = 4.7 \text{ k}\Omega$

Actuator / Motor Drive Circuit

The motor or actuator control circuit is made up of the transistor-relay switch for controlling power to the d.c motor that moves the car jack. The transistor relay switch will control power to move it the upward direction [3,11,12,13].

Relay specs:

Relay resistance = 400Ω

Relay operating Voltage = 12V

Operating Current $I_c = V / R = 12 / 400$

$I_C = 30mA$

The transistor is the C945 NPN type and the specification is shown below:

C945 NPN (silicon) Specification

$BV_{CEO} = 40V$

$BV_{CBO} = 70V$

$I_{c(max)} = 0.6A$

$P_d(watts) = 0.625W$

$H_{fe} = 100$ typical

$V_{ce(sat)} = 0.2V$

For $\beta = 100$

Base current $I_B = I_C / \beta = 30 \times 10^{-3} / 100 = 30 \times 10^{-5} A$

Base resistor $R_b = (V_{cc} - V_{be}) / I_B = (5 - 0.7) / 30 \times 10^{-5} = 14333\Omega$

A value of $15k\Omega$ was chosen as the closest standard value.

The dc motor used in the design is a 13V, 3A motor for Volkswagen car widescreen wiper. The motor is powered directly from the battery power as controlled by the relay.

Figure 8: DC motor-actuator drive circuit

Control Program

The program for the circuit was written in assembler language. The type of assembler language is the MPASM. The codes were compiled by this compiler and downloaded to the PIC16F84A [9,10].

Operational Principle of The Remote Control Car Jack

IC1 is a 555 timer astable multivibrator and its function is to generate a low frequency pulse of 68Hz to drive IC2. R1, R2 and C3 determine the frequency of oscillation of IC1.

IC2 is also a 555 timer astable multivibrator. Its function is to generate 38KHz pulse for driving the infra-red LED.

Transistor TR1 is a current amplifier for driving/boosting the output of IC2 to drive the infra-red LED. R3, R4, C4 determine the 38KHz value for IC2.

The infra-red beam is directed towards the receiver unit. The infra-red module receives the signal and demodulates it to give an output which is sent to the microcontroller. TR2 amplifies and invert the output of IR module.

The microcontroller, whenever it receives the pulses, checks for the frequency and if it is 68Hz, it enables the motor to control the jack for upward movement by sending a pulse to TR3. TR3 in turn conducts and activate the relay (RLY). The jack is controlled downwards by manually adjusting the valve for downward movement control of the jack.

Diodes D1 protects TR3 from relay switching surge currents. M is the motor to control the jack (d.c motor).

CONSTRUCTION AND TESTING CONSTRUCTION

After designing the circuit and determining components to be used and their values, the construction was embarked on.

The construction involves two parts namely the control circuit and the mechanism. The construction started with mounting of the components on a project-board (Breadboard). The project board circuit arrangement started with the power supply consisting of the limiting resistor and the voltage regulator since the other stages would need power for testing.

An assembly language code was developed for the microcontroller to control the circuit. The code was written for the microcontroller to monitor the output of the infrared sensor and decode it for the upward movement of the jack. The microcontroller and other component were placed on the project-board and wired together with jumper wires to realize the circuit. The next stage was the infra-red receiver stage followed by the motor-drive control stage which was connected with the relay in place for power control to the mechanism.

The transmitter circuit was set up on a different project board. The transmitter consists of the 555 timers, resistors, capacitors and infra-red LED. A 9V battery was used to power the transmitter circuit.

The circuit was tested after the whole circuit components have been connected as indicated by the design and circuit schematics, stage by stage to ensure they are working well.

After the test, the components were transferred to veroboard for permanent soldering. The soldering too was done stage by stage to ensure proper connection of parts and wiring. I.C sockets were used for the I.Cs, for protection of the I.Cs from soldering iron heat [11, 12, 13].

Hydraulic Jack Construction

The jack was mounted on a metal sheet and welded to it. The metal sheet measures 1 foot sq. the dc motor was welded with metal support to the point of jack.

Casing

After the complete construction work the unit was tested. The control circuit was housed in a small white panel casing. The jack,

Control Circuit and Motor Mechanism were all housed in a green metal casing.

RESULTS

The results of the test mainly presented are for the expected response of transmitter, receiver and the microcontroller response with the jack movement whenever the transmitter is pressed on and off. The result is presented in the following section and table.

Table.1 Test Results of the infra-red remote motor jack

S/No	Infra red Transmitter	Microcontroller response	Hydraulic jack response
1.	Key press#1	output voltage	Moves up
2.	Continuous Press	“	Continuous Movement

Test was also carried out on different vehicles and the result tabulated below.

Table 2: Test of Remote controlled jack on different vehicles.

Vehicle Type	Vehicle Weight (Kg)	Height of lift above ground (cm)	Maximum Time of lift (Minutes)
Toyota Camry	1359	14	2.5
BMW (5 Series)	1685	13	2.7
Mercedes Jeep	2355	11	2.8
Toyota Prado	2555	10	3.0

CONCLUSION

The project work was a success as the aims and objectives enumerated earlier were achieved.

The project work which is about the design and implementation of a remote control motor jack. The system was designed with a dc motor actuator to control the hydraulic jack up as controlled by an infra-red transmitter. The work consists of an infra-red transmitter that transmits a modulated infra-red beam towards the receiver. The receiver on reception of the weak signals, amplify and demodulate the signals and then the microcontroller receives the signal for the upward movement of the jack.

The circuit when tested worked satisfactorily as it was able to carry loads up to three tons (3Tons).

The previous chapters have highlighted the principles that have gone into realizing the infra-red remote control motor jack and also the design chapter explained steps involved in obtaining component values. These principles worked as shown by the test carried out after construction. This result did not come without some problems. The problems encountered involved adjusting component values to get accurate values with less offsets and noise as much as possible.

The project work has shown in brief, the relevant theories applied in the design. Also the design calculations were also presented in chapter three and the narration of construction and eventual testing of the project work can also be found in the write up.

The project worked satisfactory. The problem encountered was eventually taken care of.

RECOMMENDATIONS

The following recommendation has been made based on the knowledge one has acquired from the design and construction of this project and personal observations in the course of the project work.

- ❖ The use of efficient codes for better and faster response time

- ❖ The use of more efficient mechanism for the jack control and lifting of heavy loads.
- ❖ To make the project applicable for heavy duty vehicles.
- ❖ To incorporate it into the car auto system (e.g cigarette lighter sockets or clipped to the 12 volts battery)
- ❖ To increase lifting travel range from as low as 15 cm to as high as 40 cm.
- ❖ To make it more portable and user friendly.

REFERENCES

1. www.jackallcar.blogspot.com
2. http://www.tradestable.com.ng/ibadan/accessories_parts/Remote_controlled_Car_Jack_138326.htm
3. 3) Millman J.H. "INTEGRATED ELECTRONICS"; McGraw-Hill, Kogakusha Ltd, Tokyo; International Student Edition, 1972.
4. Theraja B.L. and Theraja A.K., A Textbook of Electrical Technology in SI units, S. Chand, 22nd Edition, 1999 chapter 17, 53, 56, 57, and 63.
5. Meadows R.G., "TECHNICAL ELECTRONICS II"; ELBS, 1978.
6. Whitehead R.J. "Mastering Electronics" McGraw Hill, New York, 1988, 3rd Edition, chapter 9, 10.
7. <http://www.smarthome.com/9292B/Remote-Control-Jack-E-Z-Lug-Combo/p.aspx>
8. http://www.microchip.com/stellent/idcplg?IdcService=SS_GET_PAGE&nodeId=2530. Retrieved 2 August 2011.
9. <http://www.microchip.com/downloads/en/AppNotes/00869b.pdf>. Retrieved 24 August 2009
10. <http://www.datasheetarchive.com/dl/Databooks-1/Book241-407.pdf>
11. Kanfman M. and Seidmen A.H., "Handbook of Electronics calculations for Engineers and Technicians" McGraw-Hill Book Company, New York, 1988. Chapter 3, 5, 8.
12. Green D.C. "ELECTRONICS II"; ELBS, 1998
13. Hughes E. Electrical Technology, ELBS with Longman, seventh Edition, 1995, pp 378 – 382, 392 – 400, 523 – 532.