DESIGN AND IMPLEMENTATION OF A CONTROL TOWER CRANE BY IR REMOTE CONTROL

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JULY 2013
DICLARATION OF ORIGINALITY

I declare that this report entitled “DESIGN AND IMPLEMENTATION OF A CONTROL TOWER CRANE BY IR REMOTE CONTROL” is my own work except as cited in the references.

The report has not been accepted for any degree and is not being submitted concurrently in candidature for any degree or other award.

Signature: _________________________________

Name: _________________________________

Date: _________________________________
Abstract:

A tower crane is one of the major items of equipment used in the construction of high-rise buildings. However, crane operators do not receive adequate information, such as the target space conditions and the material being lifted, to control the crane.

This limitation degrades productivity and safety. This study describes a prototype of a tower crane equipped with wireless control (IR remote control) technology. With these advanced technologies, the tower crane can provide the crane operator with an enhanced view of the workspace and various other functions providing up-to-date material status.

The tower crane can also provide faster information flow with greater accuracy and improved driving efficiency. The tower crane was used to test its performance.

The main objective of the project is to design robust, fast, and practical controllers for tower cranes to transfer loads from point to point in a short time as fast as possible and at the same time, keep the load swing small during the transfer process and completely eliminate it at the load destination. Moreover variations of the system parameters, such as the load weight are taken into account.

The results confirmed considerable improvement in operational speed and significantly enhanced performance in workplace safety and communication efficiency.
المستخلص

الرافعة البرجية هي واحدة من المعدات الرئيسية المستخدمة في تشييد المباني الشاهقة. ومع ذلك فإن مشغلي الرافعة لا يحصلون على معلومات كافية، مثل مساحة الهدف والمواد التي يجري رفعها، للسيطرة عليها هذه الأسباب وغيرها تقلل من الإنتاجية والسلامة. هذا المشروع يوضح نموذجاً أولياً لرافعة برجية بتكنولوجيا التحكم الأسلكي (الأشعة تحت الحمراء للتحكم عن بعد).

مع هذه التقنية، يمكن توفير رافعة برجية مع عرض محسن لمساحة العمل وغيرها من المهام المختلفة لإيصال المواد في الوقت المطلوب.

الهدف الأساسي لهذا المشروع هو تصميم رافعة برجية قوية يتم الحكم فيها عن طريق اجهزة تحكم لنقل الأحمال من نقطة إلى نقطة في وقت قصير في أسرع وقت ممكن ثم إنزال الحمل في المكان المراد النقل إليه، أيضاً مع الأخذ في الاعتبار بعض الوسائط في النظام ككل مثل أخذ وزن الحمولة في الاعتبار.

فكرة التحكم عن بعد للرافعة البرجية أيضاً يمكن أن توفر تدفق المعلومات بشكل أسرع وبقدر أكبر من الناقة وتحسين كفاءة القيادة. تم استخدام مجسم الرافعة البرجية لاختبار أدائها، أكدت النتائج تحسناً كبيراً في سرعة التشغيل وتعزيز الأداء بشكل كبير في السلامة في مكان العمل وكفاءة الاتصالات.
ACKNOWLEDGEMENT

First I should say thanks to Allah for helping and guiding me through this year, and giving me the strength to complete this project and write this thesis.

I am deeply indebted to my supervisor Dr. Sherif Fadhl for his patience, unlimited support, motivation, humility, continuous encouragement and great supervision.

Special thanks to Eng. Musab Makki for his cooperation, precious time, knowledge, and hard work in mechanical design and my colleagues Mohammed Elrashid and for his technical support.

Special thanks to the staff of the Department of Electrical and Electronics Engineering for their appreciated support and I would like to say that I'm really honoured to be a student in such a Department.

I wish to put on record also my gratitude to my parents and all members of my family for their continuous help and support.

At last I can’t go without saying that I am deeply indebted to our esteemed university, which I am so proud to be one of its students.
Dedication

To my supervisor Dr. Sherif Fadhl

To my Teachers

To my Friends

To my Family

To my amazing batch 084
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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>IR remote</td>
<td>infrared remote</td>
</tr>
<tr>
<td>DC motor</td>
<td>direct current motor</td>
</tr>
<tr>
<td>FCC</td>
<td>Federal Communications Commission</td>
</tr>
<tr>
<td>LED</td>
<td>light emitting diode</td>
</tr>
<tr>
<td>AGC</td>
<td>automatic gain control</td>
</tr>
<tr>
<td>AC</td>
<td>alternating current</td>
</tr>
<tr>
<td>MCU</td>
<td>Micro Controller Unit</td>
</tr>
<tr>
<td>CMOS</td>
<td>complementary metal-oxide-semiconductor</td>
</tr>
<tr>
<td>IC</td>
<td>Integrated Circuit</td>
</tr>
<tr>
<td>EMF</td>
<td>Electro Motive Force</td>
</tr>
<tr>
<td>PLC</td>
<td>programmable logic controller</td>
</tr>
<tr>
<td>HMI</td>
<td>human machine interface</td>
</tr>
<tr>
<td>IO Modules</td>
<td>input and output modules</td>
</tr>
<tr>
<td>TTL</td>
<td>transistor – transistor logic</td>
</tr>
<tr>
<td>RISC</td>
<td>Reduced Instruction Set Computer</td>
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</table>
CHAPTER 1

INTRODUCTION

1.1 Introduction:

This chapter gives an overview about the project theory and the problems it solves besides a thesis layout that informs the reader about the report elements and their description.

Cranes are widely used to transport heavy loads and hazardous materials in shipyards factories, nuclear installations, and high-building construction.

According to the record, the first tower crane used in construction-related patents issued in 1900. In 1905 appeared with fixed jib tower crane, made in 1923 the modern prototype of the tower crane, the same year the first complete modern tower crane. In 1930 the German began mass production of the tower crane, and is used for building construction.

China Tower Crane Industry in the nineteen fifties started, in relation to the Western European countries as a result of the architecture industry caused by weakness of the tower crane industry downturn, China crane industry is in a rapid development period.

1.2 Project Background:

The Tower Crane is most certainly a robust venture in terms of scope and design. The prototype, it must be noted, is clearly not full size; its structure is built primarily of wood. It utilizes the motors that give the scale model control of the full range of movement of a tower crane.

The three axes of control are:

- **Crane** rotation about the mast (gripper). This movement allows the crane to rotate until the target location is below the boom.
- Trolley movement along the boom. The trolley moves back and forth along the boom until it is directly above the target location.
- Hoisting and lowering of the cargo with a trolley mounted grapple.
The three axes are controlled by three motors that controlled by microcontroller (atmega16) which take the signals from IR remote control.

**1.3 Problem statement:**

In recent years, the vertical transport capacity of the tower crane for its high efficiency in the construction industry has a large number of applications. Domestic construction sites run the tower crane is about 70 million units, and the increase in the number of 2-3 million units per year.

Various types of tower crane operating safety accidents occur frequently, accounted for 30% of the site of major security incidents, resulting in a huge loss of life and property. The various illegal operations and overloading job is a major factor. Must be an effective means of timely and effective regulatory process and behavior of the tower crane use.

Also the problem of wasted time and the effort to qualify for working on the tower control room and the risks they might be exposed from falling or death and blurred vision angle.

Industrial production made possible through wireless control, tower crane safety and security and supervision department staff (the site security officer, tower crane rental companies, construction units, safety supervision departments) do not need to visit the site on can monitor the operation of the equipment on site.

**1.4 Motivation and objectives:**

The project goals for the Automated Tower Crane are the following:

- Build scale model of tower crane
  - Axes of movement.
  - Ability to hoist, move, and lower cargo.
- Crane with method of IR remote control.
- Software interface.
- To promote the knowledge and experience in the robotics control.
- Design and manufacturing of a robotic prototype.
Integration of the system components.

The main objective of this work is to design robust, fast, and practical controllers for tower cranes to transfer loads from point to point in a short time as fast as possible and at the same time, keep the load swing small during the transfer process and completely eliminate it at the load destination. Moreover variations of the system parameters, such as the load weight are taken into account.

1.5 Thesis layout:

This thesis was constructed from 5 chapters.

- Chapter 1 (INTRODUCTION): gives a general idea behind the project and the objectives needed to be achieved.
- Chapter 2 (LITERATURE REVIEW): will gives a detailed discussion of all the concepts and theories which relevant and use for design an implemented the control of tower crane.
- Chapter 3 (MOTHODOLOGY): will describe the design and a detailed description of all the equipment in the project, their functions and how they are connected.
- Chapter 4 (IMPLEMENTATION AND RESULTS): this chapter introduces the system implementation presenting the hardware and software details of this implementation, it also shows the systems results with a discussion part to declares in details the problems during the system development and implementation.
- Chapter 5 (Conclusions and Future work): The project is reviewed in this chapter, discussing the achieved objectives. In addition to the further developments that can be improve the resulting system.
- Appendix A: This appendix contains detailed information about the devices used in the system.
- Appendix B: This appendix contains the sketches that were used for the design of the mechanical platform.
- Appendix C: This appendix contains the code that is downloaded in microcontroller to control the rotation of the 3 motor.
CHAPTER 2

LITERATURE REVIEW

2.1 Introduction:

Crane Remote Control With the modern innovation in the wireless industrial systems many applications are designed by the reputed manufacturers in order to improve the safety of the operators and the increasing the productivity.

The modern crane remote control used in the industrial sectors greatly improves jobsite safety by providing the operator the safest vantage point for effective control of the crane. This is a one-man control remote system that eliminates the need of any second person stabilizing the load while guiding its placements. While using the system the operator has the simultaneous control to move around the work area while setting the load precisely into position. The Electrical or Hydraulic crane control wireless remote controllers apply the latest innovation in the modern remote control technology.

The system greatly reduces all types of risks during the operation. It also provides great level of security while using for the large cranes. The remote control buttons are generally specified by the customer only.

This chapter gives a brief description of the main three parts of the system which are the IR remote control, DC motor and stepper motor.

2.2 IR remote control:

A remote control is a component of an electronics device, most commonly a television set, DVD player and home theater systems originally used for operating the device wirelessly from a short line-of-sight distance. Remote control has continually evolved and advanced over recent years to include Bluetooth connectivity, motion sensor enabled capabilities and voice control.

The main technology used in home remote controls is infrared (IR) light. The signal between a remote control handset and the device it controls consists of pulses of infrared light, which is invisible to the human eye.
Infra-Red is interesting, because it is easily generated and doesn't suffer electromagnetic interference, so it is nicely used to communication and control.

The primary advantages of using IR remote control are:

1) No requirement for licensing or Federal Communications Commission (FCC) certification for use in license free bands

2) Relatively low cost

3) Safety restrictions that require the user to be close to the receiver (usually less than 150 feet) and in direct sight of the receiver.

The cheapest way to remotely control a device within a visible range is via Infra-Red light. Almost all audio and video equipment can be controlled this way nowadays. Due to this wide spread use the required components are quite cheap, thus making it ideal for us hobbyists to use IR control for our project. This part explains the theory of operation of IR remote control.

### 2.2.1 Infra-Red Light:

Infra-Red actually is normal light with a particular colour. We humans can't see this colour because its wave length of 950nm is below the visible spectrum. That's one of the reasons why IR is chosen for remote control purposes, we want to use it but we're not interested in seeing it. Another reason is because IR LEDs are quite easy to make, and therefore can be very cheap.

Although we humans can't see the Infra-Red light emitted from a remote control doesn't mean we can't make it visible. A video camera or digital photo camera can "see" the Infra-Red light as it can see in this picture.
Unfortunately there are many more sources of Infra-Red light. The sun is the brightest source of all, but there are many others, like: light bulbs, candles, central heating system, and even our body radiate Infra-Red light. In fact everything that radiates heat also radiates Infra-Red light.

**2.2.2 Modulation:**

Modulation is the answer to make our signal stand out above the noise. With modulation we make the IR light source blink in a particular frequency. The IR receiver will be tuned to that frequency, so it can ignore everything else.

![Diagram](image)

**Figure 2-2** a modulated signal driving the IR LED of the transmitter on the left side. The detected signal is coming out of the receiver at the other side.

**2.2.3 The transmitter:**

The transmitter usually is a battery powered handset. It should consume as little power as possible, and the IR signal should also be as strong as possible to achieve an acceptable control distance.

Quartz crystals are seldom used in such handsets. They are very fragile and tend to break easily when the handset is dropped. Ceramic resonators are much more suitable here, because they can withstand larger physical shocks.

The current through the LED (or LEDs) can vary from 100mA to well over 1A! In order to get an acceptable control distance the LED currents have to be as high as possible. A trade-off should be made between LED parameters, battery lifetime and maximum control distance. LED currents can be that high because the pulses driving the LEDs are very short. Average power dissipation of the LED should not exceed the maximum value though.

A simple transistor circuit can be used to drive the LED. A transistor with a suitable HFE (the small signal Forward Current Gain of a bipolar junction transistor) and switching speed should
be selected for this purpose.

The resistor values can simply be calculated using Ohm's law, the nominal voltage drop over an IR LED is approximately 1.1V.

![Figure 2-3 simple transistor circuit can be used to drive the LED](image)

The normal driver, described above, has one disadvantage. As the battery voltage drops, the current through the LED will decrease as well. This will result in a shorter control distance that can be covered. An emitter follower circuit can avoid this. The 2 diodes in series will limit the pulses on the base of the transistor to 1.2V. The base-emitter voltage of the transistor subtracts 0.6V from that, resulting in constant amplitude of 0.6V at the emitter. This constant amplitude across a constant resistor results in current pulses of a constant magnitude. Calculating the current through the LED is simply applying Ohm's law again.

![Figure 2-4 two diodes in series simple transistor circuit](image)

### 2.2.4 The Receiver:

![Figure 2-5 block diagram of such an IR receiver.](image)

In the picture above a typical block diagram of such an IR receiver. The received IR signal is picked up by the IR detection diode on the left side of the diagram. This signal is amplified and limited by the first 2 stages. The limiter acts as an AGC circuit to get a constant pulse level,
regardless of the distance to the handset. The AC signal is sent to the Band Pass Filter, the Band Pass Filter is tuned to the modulation frequency of the handset unit. Common frequencies range from 30 kHz to 60 kHz in consumer electronics. The next stages are a detector, integrator and comparator. The purpose of these three blocks is to detect the presence of the modulation frequency. If this modulation frequency is present the output of the comparator will be pulled low.

All these blocks are integrated into a single IR receiver.

Figure 2-6 IR receiver.

Figure 2-7 IR remote control.
2.3 Electrical Motor:

2.3.1 Types Classification and History of Motor:

The motor or an electrical motor is a device that has brought about one of the biggest advancements in the fields of engineering and technology ever since the invention of electricity. A motor is an electro-mechanical device that converts electrical energy to mechanical energy. Without motor we had still been living in Sir Thomas Edison’s Era where the only purpose of electricity would have been to glow bulbs. There are different types of motor have been developed for different specific purposes.

In simple words a device that produces rotational force is a motor. The very basic principal of functioning of an electrical motor lies on the fact that force is experienced in the direction perpendicular to magnetic field and the current, when field and electric current are made to interact with each other. Ever since the invention of motors, a lot of advancements have taken place in this field of engineering and it has become a subject of extreme importance for modern engineers.

2.3.1.1 Classification or Types of Motor:

The primary classification of motor or types of motor can be described as shown below:

![Classification of Motor Diagram](image)

Figure2-8 classification of motor or types of motor

Here is a description of main motors which were used it in this project (stepper motor and DC motor).
2.3.2. Stepper motor:

2.3.2.1 Introduction:

A stepper motor is a brushless, synchronous electric motor that converts digital pulses into mechanical shaft rotation. Every revolution of the stepper motor is divided into a discrete number of steps, in many cases 200 steps, and the motor must be sent a separate pulse for each step.

The stepper motor can only take one step at a time and each step is the same size. Since each pulse causes the motor to rotate a precise angle, typically 1.8°, the motor's position can be controlled without any feedback mechanism.

As the digital pulses increase in frequency, the step movement changes into continuous rotation, with the speed of rotation directly proportional to the frequency of the pulses. Step motors are used every day in both industrial and commercial applications because of their low cost, high reliability, high torque at low speeds and a simple, rugged construction that operates in almost any environment.

Stepper motors have emerged as cost-effective alternatives for DC servomotors in high-speed, motion-control applications (except the high torque-speed range) with the improvements in permanent magnets and the incorporation of solid-state circuitry and logic devices in their drive systems.

Today stepper motors can be found in computer peripherals, machine tools, medical equipment, automotive devices, and small business machines, to name a few applications.

Figure 2-9 stepper motor
2.3.2.2 COMMON CHARACTERISTICS OF STEPPER MOTORS:

Stepper motors are not just rated by voltage. The following elements characterize a given stepper motor:

2.3.2.2.1 Voltage:

Stepper motors usually have a voltage rating. Exceeding the rated voltage is sometimes necessary to obtain the desired torque from a given motor, but doing so may produce excessive heat and/or shorten the life of the motor.

2.3.2.2.2 Resistance:

Resistance-per-winding is another characteristic of a stepper motor. This resistance will determine current draw of the motor, as well as affect the motor's torque curve and maximum operating speed.

2.3.2.2.3 Degrees per step:

This is often the most important factor in choosing a stepper motor for a given application. This factor specifies the number of degrees the shaft will rotate for each full step. Half step operation of the motor will double the number of steps/revolution, and cut the degrees-per-step in half. For unmarked motors, it is often possible to carefully count, by hand, the number of steps per revolution of the motor. The degrees per step can be calculated by dividing 360 by the number of steps in 1 complete revolution. Common degree/step numbers include: 0.72, 1.8, 3.6, 7.5, 15, and even 90. Degrees per step is often referred to as the resolution of the motor.

2.3.2.3 Unipolar Motors:

Unipolar stepping motors, both Permanent magnet and hybrid stepping motors with 5 or 6 wires are usually wired as shown in the figure 2-10, with a center tap on each of two windings. In use, the center taps of the windings are typically wired to the positive supply, and the two ends of each winding are alternately grounded to reverse the direction of the field provided by that winding. As shown in the figure, the current flowing from the center tap of winding 1 to terminal a causes the top stator pole to be a north pole whiles the bottom stator pole is a south pole.
Figure 2-10 unipolar stepper motor

This attracts the rotor into the position shown. If the power to winding 1 is removed and winding 2 is energized, the rotor will turn 30 degrees, or one step.

To rotate the motor continuously, we just apply power to the two windings in sequence. Assuming positive logic, where a 1 means turning on the current through a motor winding, the following two control sequences will spin the motor illustrated in the figure.

2.3.2.3.1 Operation of unipolar stepper motor:

Figure 2-11 two phase stepper-motor wiring diagram

The above motor is a two-phase motor. The two-phase coils are center-tapped and in this case the center-taps are connected to ground. The coils are wound so that current is reversed when the drive signal is applied to either coil at a time. The north and south poles of the stator phases reverse depending upon whether the drive signal is applied to coil 1 as opposed to coil 2.
2.3.2.3.2 Step sequence:

There are three modes of operation when using a stepper motor. The mode of operation is determined by the step sequence applied. The three step sequences are:

2.3.2.3.2.1 Wave stepping:

The wave stepping sequence is shown below:

Table 2-1 wave stepping sequence

<table>
<thead>
<tr>
<th>Step</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>2</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>3</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>

Figure 2-12 rotating unipolar wave stepping

Wave stepping has less torque than full stepping. It is the least stable at higher speeds and has low power consumption.

2.3.2.3.2.1.1 Full stepping:

The full stepping sequence is shown below:

Table 2-2 full stepping sequence

<table>
<thead>
<tr>
<th>Step</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
</tbody>
</table>
Full stepping has the lowest resolution and is the strongest at holding its position. Clockwise and counter clockwise rotation is accomplished by reversing the step sequence.

2.3.2.3.2.1.2 half stepping:

The half-step sequence is shown below:

<table>
<thead>
<tr>
<th>Step</th>
<th>L1</th>
<th>L2</th>
<th>L3</th>
<th>L4</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>2</td>
<td>H</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>3</td>
<td>L</td>
<td>H</td>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>4</td>
<td>L</td>
<td>H</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>5</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>L</td>
</tr>
<tr>
<td>6</td>
<td>L</td>
<td>L</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>7</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
<tr>
<td>8</td>
<td>H</td>
<td>L</td>
<td>L</td>
<td>H</td>
</tr>
</tbody>
</table>
2.3.3 Dc Motor:

2.3.3.1 The Ampere's rule (the right-hand screw rule):

It is Frenchman Andre-Marie Ampere (1775–1836), a mathematician and physicist, who discovered what happens to a wire wound in a coil when current flows within. The current will generate a magnetic field around the coil, as shown in the following drawing:
Using your right hand, you can find out the direction of the magnetic lines as well as the North Pole orientation. Close your fist and hold your thumb upwards, like thumbs-up. If you had the coil inside your hand and your fingers (except the thumb) was showing the direction of the current, then the thumb shows the direction of the magnetic lines as well as the orientation of the North pole. This is called "the right-hand screw rule".

The basic DC motor has actually two windings and two permanent magnets. The coils are powered from the commutator and the brushes, during a full cycle of the rotor, the current that runs through each winding change direction once. Thus, each electromagnet will change its magnetic polarity. Moreover, the windings of the two magnets are winded in reversed direction. Thus, when one electromagnet is north, the other is south and vice versa. Look at the following drawing of the basic DC motor:

![Figure 2-16 basic parts of DC motor](image)

**2.3.3.2 The commutator and the brushes of a DC motor:**

This kind of DC motor is called "Brushed DC motor", Because it uses brushes... The brushes are the way that the motor provides the coils with power, and the geometrical characteristics and position of the brushes (and the commutator of course) will be responsible for changing the magnetic field of the two electromagnets according to the position of the rotor. So the brushes are two metallic pieces that act like springs. On one side, they have a piece of conductive material, usually made of carbon to stand against friction. On the other side, they have the pin that the power supply is applied to the motor. The brushes are pushed (by the spring action of the metallic part) against the commutator. The commutator is a metallic ring, also conductive and able to stand
friction that is divided in two parts. The following drawing explains how these parts are:

![Brushed DC motor diagram](image)

**Figure2-17 Brushed DC motor**

The commutator is fixed on the shaft of the motor. Each semi-ring has one pole of each coil. Giving thus power to both half-rings, is like giving power to the coils. But while the shaft of the motor rotates, the commutator rotates as well. This causes the poles of the power supply provided to the coils to change. This change of the electric poles has an effect on the magnetic poles as well. The current direction is changed and - due to the rule of the right-hand screw - the poles of the electromagnets will also change.

![Electric and magnetic polarity change](image)

**Figure2-18 shows how the electric and magnetic polarity is changed.**
CHAPTER 3

METHODOLOGY

3.1 Introduction:

In this chapter, the tower crane design will be presented. The main objective of the project is to control the motion of tower crane by 3 motors according to signals from IR remote control. Starting from sending the signal from the remote control and IR receiver detects the signal and sent it to microcontroller which apply the function of each signal to control the motion of tower crane by the motors.

3.2 IR Remote control:

Pushing a button on a remote control sets in motion a series of events that causes the controlled device to carry out a command. The process works something like this:

When the "volume up" button on remote control pressed, causing it to touch the contact beneath it and complete the "volume up" circuit on the circuit board. The integrated circuit detects this and sends the binary "volume up" command to the LED at the front of the remote. The LED sends out a series of light pulses that corresponds to the binary "volume up" command. This process worked for all other buttons in the remote.

Figure 3-1 shows the 11 pulses that are generated (7 pulses for command and 4 pulses for address)
The remote-control codes, which used includes the following 7-bit binary commands, the following table show the buttons, its commands and the function of each buttons which used to control the crane.

**Table 3-1 show the button, button’s command and button’s function**

<table>
<thead>
<tr>
<th>Button</th>
<th>Command</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Button 1</td>
<td>000 0000</td>
<td>Move dc motor toward the beginning of the arm</td>
</tr>
<tr>
<td>Button 2</td>
<td>000 0001</td>
<td>Move dc motor inside the end of the arm</td>
</tr>
<tr>
<td>Channel up</td>
<td>001 0001</td>
<td>Rise up the load.</td>
</tr>
<tr>
<td>Channel down</td>
<td>001 0011</td>
<td>Lower the load</td>
</tr>
<tr>
<td>OK</td>
<td>011 0111</td>
<td>Stop the DC motor</td>
</tr>
<tr>
<td>Volume up</td>
<td>001 0010</td>
<td>Rotate the crane clockwise</td>
</tr>
<tr>
<td>Volume down</td>
<td>001 0011</td>
<td>Rotate the crane anti clockwise</td>
</tr>
<tr>
<td>Power on</td>
<td>001 0101</td>
<td>Start up the system</td>
</tr>
<tr>
<td>Power off</td>
<td>010 1111</td>
<td>Shut down the system</td>
</tr>
</tbody>
</table>

### 3.2.1IR Receiver module:

So when the button on a remote pressed, IR remote control sends out a series of pulses and the infrared receiver picks up these pulses and verifies from the address code that it's supposed to carry out this command, it converts the light pulses back into the electrical signal sequence.

It then passes this signal to the microcontroller (atmega16) , which apply the function of button which was pressed.
3.3 The Controller:

The atmega16 received the signal from IR receiver and referring to the code which downloaded in it, the function of the button will apply on the motors according to this signal.

3.4 The stepper motor:

The stepper turned out to be a 4-phase unipolar stepper with 4 windings. One endpoint of each winding is connected to a common wire, so there are 5 wires altogether coming out of the motor. Each winding is actually used 12 times around the motor, which gives 48 steps of 7.5 degrees each. When current flows between the common connection and one of the 4 endpoints of the windings, this creates a magnetic field that causes the rotor to align with that winding. If current stops flowing in that winding but starts flowing in an adjacent one, the rotor will step to align with the energized winding.

The atmega16 is not good at pushing current. It can sink 25mA, but it can only source 100uA, not enough to drive a stepper directly. So ULN2803 was used, this chip contains 8 Darlington pairs that can each sink 500mA, and each output comes with a built-in protection diode. Because the Darlington pairs use bipolar transistors, you need to push more than 1mA into an input of the ULN2803 to saturate the corresponding output. ULN2803 has 8 Darlington pairs therefore, the controller can drive two steppers of the same type at the same time.

3.4.1 The stepper motor 1:

So when “volume up” button was pressed it cause energizing the windings in one cyclic order “1-2-3-4-1-2-3-4”, this cause the motor to rotate in one direction (the arm rotate in a clockwise), and when “volume down” button was pressed, it energizing them in the opposite cyclic order 1-4-3-2-1-4-3-2 that cause the motor to rotate in the other direction (the arm rotate anticlockwise), the rotation is discrete, in steps of 7.5 degrees.

3.4.2 The stepper motor 2:

when “button1” was pressed it cause energizing the windings in one cyclic order “1-2-3-4-1-2-3-4”, this cause the motor to rotate in one direction and cause the block that carry DC motor to
move in horizontal line toward the end of arm, and “button 2” was pressed, it energizing them in the opposite cyclic order 1-4-3-2-1-4-3-2 that cause the motor to rotate in the other direction and cause the block that carry DC motor to move in horizontal line toward the begin of arm, the rotation is discrete, in steps of 7.5 degrees.

3.5 The DC Motor:

DC Motors convert electrical energy (voltage or power source) to mechanical energy (produce rotational motion). They run on direct current. The Dc motor works on the principle of Lorentz force which states that when a wire carrying current is placed in a region having magnetic field, than the wire experiences a force. This Lorentz force provides a torque to the coil to rotate.

To drive a motor, it cannot be connected it direct to the microcontroller, because the MCU will generate signals in form of HIGH (Vcc = 5v) or LOW (zero). But this voltage is insufficient to drive a motor. That’s why Motor Driver was used. The most commonly used motor driver is the L293D. It is a H-Bridge (four transistor) Motor Drivers that can handle a continuous peak output current of 650miliampere.

Once the motor is running, it generates a voltage similar to moving a wire through a magnetic field to produce what is called back EMF. The way to counteract this is to place a general purpose diode across the leads of the motor allowing current to flow in only one direction thus counteracting the back Electro Motive Force. But one of the things that makes the L293D chip unique is that it has these diodes that were built into the chip.

The following figure describes the circuit inside the driver (L293D) for how can DC motor derived by it:

![Figure3-2 the circuit inside the L293D](image-url)
When the “channel up” button was pressed, it give high value to transistor Q1 and Q3. So Q1 and Q3 will be ON. Current will flow from Vcc to Ground via Q1-Motor-Q3. And the motor will rotate clock wise (as shown in the following figure) to rise up the load that was carried.

![Figure 3-3 show how driver rotate DC motor clockwise](image)

And when “channel down” button was pressed it giving high value to transistor Q2 and Q4. So Q2 and Q4 will be ON. Current will flow from Vcc to Ground via Q2-Motor-Q4. And the motor will rotate anti clock wise (as shown in the following figure ) to fall down the load that was carried.

![Figure 3-4 show how driver rotate DC motor anti clockwise](image)

Also when “OK” button was pressed it give high value to transistor Q1 and Q4. So Q1 and Q4 will be ON. Current will flow from Vcc to Ground via Q1-Q4. It will not at all pass through the motor (as shown in the following figure). So the DC motor will not rotate.
A motor driver always has a battery input $V_s$ (which depends upon the rating of the motor) that it directs the $V_s$ voltage to the motors connected to it. Thus, the motors behave as per the control signals generated using the MCU but are operated by the external battery voltage.

### 3.6 Mechanical platform:

It is done using computer aided design software (Solid work) considering the required torque and speed.

These are figures show the platform of the design with different views:

![Figure 3-6: The mechanical platform or the robot of the tower crane](image)

Figure 3-5 shows how driver stop DC motor.
Figure 3-7 the mechanical platform or the robot of the tower crane from the top

Figure 3-8 the mechanical platform or the robot of the tower crane from another view
CHAPTER 4

IMPLEMENTATION AND RESULTS

4.1 Introduction:

This chapter shows the implementation details of the control crane wirelessly, including a brief description of the software and hardware components that were used in the project including all the circuit components.

4.2 Project implementation:

In this section of the chapter all the implementation details will be mentioned including that used for actual implementation.

4.2.1 Hardware components:

4.2.1.1 The Atmega16 Microcontroller:

The ATmega16 is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega16 achieves throughputs approaching 1 MIPS per MHz allowing the system designed to optimize power consumption versus processing speed.

Figure 4-1 microcontroller atmega16
4.2.1.2 Unipolar stepper motor:

Unipolar stepping motors, both Permanent magnet and hybrid stepping motors with 5 or 6 wires are usually wired as shown in the figure 4-2, with a center tap on each of two windings. In use, the center taps of the windings are typically wired to the positive supply, and the two ends of each winding are alternately grounded to reverse the direction of the field provided by that winding. As shown in the figure, the current flowing from the center tap of winding 1 to terminal a causes the top stator pole to be a north pole whiles the bottom stator pole is a south pole.

![Unipolar stepper motor from inside](image)

This attracts the rotor into the position shown. If the power to winding 1 is removed and winding 2 is energized, the rotor will turn one step.

To rotate the motor continuously, we just apply power to the two windings in sequence. Assuming positive logic, where a 1 means turning on the current through a motor winding, the following two control sequences will spin the motor illustrated in the figure.

![Unipolar stepper motor](image)
4.2.1.3 DC motor:

(DC) motor is use electricity and a magnetic field to produce torque, which causes it to turn. At its most simple, it requires two magnets of opposite polarity and an electric coil, which acts as an electromagnet. The repellent and attractive electromagnetic forces of the magnets provide the torque that causes the motor to turn.

Dc motor is comprised of two basic parts the rotor, the moving part and the stator, the stationary part and generally have 3 poles.

When working with DC motors, there are two current ratings, the first is the operating current, this is the average amount of current that the motor will consume while running under normal conditions. The next is the stall current that can be best demonstrated if the shaft of the motor is hold with fingers so that it cannot turn and apply power.

![Figure 4-4 DC motor](https://www.electronic.en.alibaba.com)

4.2.1.4 IR Receiver:

An infrared receiver, or IR receiver, is hardware that sends information from an infrared remote control to another device by receiving and decoding signals. In general, the receiver outputs a code to uniquely identify the infrared signal that it receives. This code is then used in order to convert signals from the remote control into a format that can be understood by the other device.
Here IR receiver were used for decoding signals that come from the remote control and send it to the microcontroller (atmega16) to perform the function of this signal (button which is pressed).

![IR receiver module]

Figure 4-5 IR receiver module

4.2.1.5 ULN2803 driver chip:

The microcontroller has far too little current output sinking capability to drive this stepper motor. Therefore, we will use the ULN2803 driver chip to interface to the motor.

This device contains 8 bipolar power transistors, configured as “Darlington drivers”. Each of the outputs is independently controllable.

The output of each driver transistor is open collector. The strategy was used four of these outputs to drive the four windings of the stepper motor. Each output, when asserted, must be able to sink the current flowing through its respective winding of the motor.
4.2.1.6L293D driver chip:

L293D is a dual H-Bridge motor driver, so with one IC it can be interface two DC motors which can be controlled in both clockwise and counter clockwise direction. L293D has output current of 600mA and peak output current of 1.2A per channel. Moreover for protection of circuit from back EMF output diodes are included within the IC.

A simple schematic for interfacing a DC motor using L293D is shown below.
Figure 4-8 show how DC motor connected to L293D

Figure 4-9 L293D

4.2.1.7 IR remote control:

Remote controls are Consumer IR devices used to issue commands from a distance to televisions or other consumer electronics such as stereo systems, DVD players and dimmers. Remote controls for these devices are usually small wireless handheld objects with an array of buttons for adjusting various settings such as television channel, track number, and volume. In fact, for the majority of modern devices with this kind of control, the remote control contains all the function controls while the controlled device itself has only a handful of essential primary controls.
Figure 4-10 IR remote control

Figure 4-11 The Hardware implementation
4.2.2 Software components:

The software component that used during the development of the project is:

4.2.2.1 BASCOM AVR:

BASCOM AVR is a very powerful and easy-to-use compiler for the AVR series of micro controllers developed by Atmel. The program comes with a very user-friendly interface and a set of simple commands, and provides more flexibility than other programs in this category.

Anybody with some basic knowledge of C or C++ can write a successful program using BASCOM, as most of its functions and its statement structure is similar to those in C.

it was used for the development of the controller code in the Atmega16 microcontroller of this project.

4.3 The results and discussion:

![Figure 4-12 shows the DC motor raises the load](image)

*Figure 4-12 shows the DC motor raise the load*
Figure 4-13 the DC motor lowers the load

Figure 4-14 the block that carry DC motor at the beginning of the arm
In this project IR remote control was used regardless of radio frequency remote because the project it’s just a small prototype and no need to operate it from a long distance (more than 10 meters so infrared remote control was used and have range of only 30 feet (10 meters).

The infrared-light didn’t interfaces with other sources of infrared-light such as sunlight, fluorescent bulbs and the human body because the infrared receiver only responds to a particular wavelength. but still sunlight can confuse the receiver because it contains infrared light at the 980-nm wavelength. to address this issue, the light from an IR remote control is typically modulated to a frequency not present in sunlight, and the receiver only responds to 980-nm light modulated to that frequency. The remote doesn't work perfectly, but it does cut down a great deal on interference.
The initial consideration is that if the torque of the stepper motor 1 is enough to rotate the arm of the crane and by some calculation the weight of the arm and related to the torque, it was given that this torque can rotate the arm but unfortunately during the manufacturing of the prototype crane some problems was appeared and to avoid these problems, some wood and iron was established in the arm and so that problems was solved but also appeared another problem that is the weight of the arm was increased by that addition of wood and iron and the stepper motor- with the initial torque- found difficult to rotate the arm, these problem wasn’t solved by that the power input to the stepper motor 1 was increased and also another solution was tried but with no result for this high weight.

The stepper motor 2 was worked perfectly and did its function –the movement of block that carries the DC motor- without any problem.

the DC motor was worked and did its function- hoisting and lowering of the cargo with a trolley mounted grapple- but the problem that was appeared during the designing of electrical circuit that was the DC motor rotate with high speed, this high speed was reduced by that the frequency of PWM was increase but still the speed was little bit high, mechanically this problem could solve by using GEARBOX but this problem was detected too late. with some more time this GEARBOX could be used.

After the implementation of the project was finished, it was noticed that the mechanical problems were more than electrical problems, the electrical problems was solved but the mechanical problems was solved as much as possible.
Chapter 5

Conclusion and future work

5.1 Conclusion

The IR remote control unit was used to operate a crane that can rotate from side to side, raise and lower a gripper, and pick up small objects. The IR remote control was worked well and before it was used in this project, some practice on DC motor and stepper motor were done and it was found that the IR remote control is not complicated for utilization.

The continuous rotation DC motor turns smoothly and the one of the two stepper works well but the other one has some problem in torque related to the weight of the arm of the crane. Overall the motors crane work alright and are a little bit too sensitive to small movements by the IR remote control.

The idea for this project was to track 3d points with Wiimote, and it eventually changed this to one IR remote control after having trouble getting the remote software program (darwiineRemote) to work with it.

Once we got the remote working and sending data to the MCU we had to come up with an application of the IR tracking. Building a crane seemed like a good combination of software and hardware.

with some more time the crane could built with a stronger frame and more aesthetics and also the problem of the torque of stepper 1 related to the weight of the arm
5.2 Future work

Many heavy industries, such as steel refineries, mines, offshore applications, and shipyards, use cranes as part of their daily operations.

Given the mobile nature and operating environments of crane applications, installing cabling is often impractical or expensive, and remote control and monitoring systems on cranes may not be able to connect reliably to plant networks.

Wireless radio remote control for crane offer an integrated solution for almost any application. Replace a PLC, HMI, IO Modules and Radio link with a single Orbit, wireless control unit is used.

There is no need to use a PLC and a bunch of relays or timers to satisfy your specific requirements for remote monitoring or control. Wireless radio remote control systems provide user-programmable function, flexible input/output all rolled into one device.

With wireless radio remote switching and monitoring systems it can be easily move a crane in all directions & emergency stop will be provided and much more.

The range of Wireless Input and Output devices provide excellent solutions for industrial applications. These systems can be used to remotely monitor industrial machinery, control processes and provide alarm notification. Systems are available with ranges from several meters.

Also camera it will be used and allocated in the top of crane of industrial machine to give all information in the work field and the operator can stay away from this field to avoid himself from accidents.
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10) http://bascom-avr.software.informer.com/
Appendix A: HARDWARE

Microcontroller:

![Atmega16 MCU Diagram]

Figure_apx A-1  Atmega16 MCU
IR Receiver:

Figure_apx A-2  IR Receiver
Stepper motor:

OUTLINE

Standard type motor "M42SP-7" which belongs to the outer diameter 42mm model series. Despite 7.5° of step angle, and excitation method that are all in common with "M42SP-5", its body has been reduced to 15.7mm in thickness. This type is the most suited to any compact electronic apparatuses.

FEATURES

1. High output torque.
2. Superior running quietness and stability.
4. Excellent responsiveness acquired.
### SPECIFICATIONS

<table>
<thead>
<tr>
<th>Item</th>
<th>M42SP-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rated Voltage</td>
<td>DC 12V</td>
</tr>
<tr>
<td>Working Voltage</td>
<td>DC 10.8–13.2V</td>
</tr>
<tr>
<td>Rated Current/Phase</td>
<td>259mA</td>
</tr>
<tr>
<td>No. of Phase</td>
<td>4 Phase</td>
</tr>
<tr>
<td>Coil DC Resistance</td>
<td>50Ω/phase±7%</td>
</tr>
<tr>
<td>Step Angle</td>
<td>7.5°/step</td>
</tr>
<tr>
<td>Excitation Method</td>
<td>2-2 Phase excitation (Unipolar driving)</td>
</tr>
<tr>
<td>Insulation Class</td>
<td>Class E insulation</td>
</tr>
<tr>
<td>Holding Torque</td>
<td>49.0mN·m</td>
</tr>
<tr>
<td>Pull-out Torque</td>
<td>23.5mN·m/200pps</td>
</tr>
<tr>
<td>Pull-in Torque</td>
<td>19.6mN·m/200pps</td>
</tr>
<tr>
<td>Max. Pull-out Pulse Rate</td>
<td>600pps</td>
</tr>
<tr>
<td>Max. Pull-in Pulse Rate</td>
<td>420pps</td>
</tr>
</tbody>
</table>

### CHARACTERISTICS

![Graphs of M42SP-7 (50Ω, 12V DC) and M42SP-7 (150Ω, 24V DC)]

### DIMENSIONS

![Dimensions diagram]

Unit: mm, General tolerance: ±0.5

Figure_apx A-3 stepper motor
Dc motor:

Figure_apx A-4 DC motor
L293D:

![L293D Diagram]

Figure_apx A-5 L293D
ULN2803:

Figure_apx A-6 ULN2803
Appendix B: MECHANICAL DESIGN

Main axel:

Figure_apx B-1  main axel
the main arm:

Figure_apx B-2 main arm
Dc motor holder:

![DC Motor Holder Diagram](image_url)

Figure_apx B-3 Dc motor holder
The crane assembly:

Figure_apx B-4 Crane assembly
Appendix C: THE CODE

$regfile "m16def.dat"

$crystal = 1000000

Config Portb = Output

Config Timer1 = Pwm , Pwm = 10 , Prescale = 1 , Compare A Pwm = Clear Down , Compare B Pwm = Clear Down

Config Rc5 = Pinc.0

Enable Interrupts

Dim I As Integer , X As Byte , Y As Byte

I = 0

Do

Getrc5(x , Y)                                              'Read IR signal(Address, command)

Y = Y And &B01111111                      'Masking (convert command to the button no.)

If Y <> 3 And Y <> 6 Then

Compare1a = 0

End If

'i if button pressed is not equal to 3 or 6 stop dc motor

End If

'i*****************************************************************

If Y = 1 Then                                              'if button 1 pressed move motor1 forward

Portb.i = 1

Waitms 500

Portb.i = 0
Appendix C

The Code

I = I + 1

If I > 3 Then I = 0

End If

'*************************************************

If Y = 4 Then

Portb.i = 1                                              'if button 4 pressed move motor1 backward

Waitms 500

Portb.i = 0

I = I - 1

If I < 0 Then I = 3

End If

'*************************************************

If Y = 2 Then

Portb.i = 1                                              'if button 2 pressed move motor2 forward

Waitms 10

Portb.i = 0

I = I + 1

If I > 7 Then I = 4

End If

'*************************************************

If Y = 5 Then

Portb.i = 1                                              'if button 5 pressed move motor2 backward
Appendix C

The Code

Waitms 10

Portb.i = 0

I = I - 1

If I < 4 Then I = 7

End If

'**************************************************

If Y = 3 Then

'if button 3 pressed move motor3 forward

Compare1a = 500

Compare1b = 0

End If

'**************************************************

If Y = 6 Then

Compare1a = 0

Compare1b = 500

'if button 6 pressed move motor3 backward

End If

Loop