The idea of this paper targets severely injured patients who have to be operated upon immediately. In critical cases, the patient is advised not to be moved frequently; but moving him from the stretcher to the operation theatre table is inevitable. Hence wheels have been attached to the table itself for easy movement. The wheels can be locked when surgery is being performed, so that the table is steady. The need not be moved or turned on the table to operate on the affected parts; this is accomplished by giving rotation to the table to the required angle. The model of this work has four degrees of freedom. It has one linear motion and three rotational motions. The bed is divided into three parts. Two micro-controller units are used along with an IR-TSOP1738 transmitter and IR-TSAL7300 receiver in a remote control system. Using this, the parts can be individually turned or titled to the required angle. The other merits of using this bed include; the patient need not be shifted to another bed after surgery, as the model serves the purpose of operation theatre table and a bed, the patient himself can adjust the bed to his comfort, regular monitoring of the patient is done by incorporating temperature sensors. The main objective of the paper is to develop a wireless remote to operate the multi axis operation theatre table.

Abstract

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Keywords: Micro Controller, Wireless remote control system, transmitter, receiver

I. Introduction

Surgery is an area of vital importance in the field of medicine. Surgery was originally performed on operating chairs; which were then replaced by tables. The first operation theatre table was more-or-less an ordinary wooden table. This table posed many problems to the surgeon and the patient for critical surgeries. The conventional operation theatre table has undergone many changes to answer to the problems faced during surgery. To overcome this problem, the bed is divided into three parts. Two micro-controller units are used along with an IR-TSOP1738 transmitter and IR-TSAL7300 receiver in a remote control system. Using this, the parts can be individually turned or titled to the required angle. By this, the desired position is achieved. When the button is pressed, the signal is transferred from the remote to 2051 Micro-Controller which is then encoded by the HT12A encoder and sent to the transmitter. This transmitted signal is received by the receiver; the signal is decoded by the the HT12D decoder and the decoded signal is sent to the 8051 Micro-controller which controls the motors as required through the L239 Micro-controller.

An operating table, on which the patient lies during a surgical operation. This is a vital equipment of the operation theatre. There are different types of operation tables namely

- Single Hydraulic cylinder
- Hydraulic Head End Control Operation Table Remote Controlled
- C- Arm Compatible

An operating table has different positions for the convenience of performing the operation at the surgical area. Different positions include Standard Supine position, Trendelenburg, Reverse Trendelenburg position, Lateral Tilt position, Kidney position, Thoracic Abdominal position, Chair/sitting position, Kneeling position, Lithotomic position. In addition there are certain operation table accessories as well. Three different positions of OT table are as shown in fig.1

1.1 Problems faced with existing OT table

Currently, the OT tables are being utilised with the help of remotes connected to the table by means of coiled spring. This coiled spring has certain limitations:

- The connection link between the remote and table i.e. the coil can be dislocated leading to a problem.
- Presence of wires adds to the complexity and needs more maintenance which may cost time and labour.
- Difficulty in cleaning under the equipment due to bulkiness and non-compact design.
• Shifting of the patient from the OT table to hospital bed after surgery is inevitable and also difficult.

This paves the way for the development of a wireless remote to control the operation bed which will avoid the above mentioned drawbacks. Wireless remote marks the advancement in the technology. There are two major parts of this paper is:

• Wireless remote
• Bed

1.1.1 Wireless Remote

A remote control is a component of an electronics device, most commonly a television set, DVD player and home theatre systems originally used for operating the device wirelessly from a short line-of-sight distance. The main technology used in 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, but can be seen through a digital camera, video camera or a camera phone. The transmitter in the remote control handset sends out a stream of pulses of infrared light when the user presses a button on the handset. A transmitter is often a light emitting diode (LED) which is built into the pointing end of the remote control handset. The infrared light pulses form a pattern unique to that button. The receiver in the device recognizes the pattern and causes the device to respond accordingly. General specifications of wireless remote are:

• Water proof - This feature ensures that the remote will not get affected when in contact with water.
• Easy to operate - Easy to operate remote will avoid any sort of confusion that may occur to the user.
• Charging should last for 3-4 hours. The remote should be able to function even under charging mode.

The transmitter block diagram (fig.2) consists of switches, microcontroller, encoder and IR transmitter.

In a nutshell, IR is the medium for communication. Remote control sends the commands which are received at receiver end. Once the commands are scanned and read, the necessary output action can be observed. The vital component being used is the microcontroller as it has the program dumped in it.
1.2 Schematic Diagrams

In the schematic diagram of the remote panel, the sixteen switches shown resemble the keys on the remote key board is shown in fig.4. These sixteen switches( form a 4x4 matrix) are connected to the pins 12,13,14,15,16,17,18,19 of the microcontroller 2051 which is basically a 8-bit one. 2051 can direct LED drive output, has two ports namely Port1 and Port 3. When a key is pressed on the remote, data is selected and this 8 bit data is sent to the microcontroller 2051 port 1. Later, when the transmission pin of 2051 is enabled (P3.1 TXD), a 4-bit data is sent to the Encoder HT12A from microcontroller. This data is received at pins 10,11,12,13 (D8-D11, active low, transmission enable). The input pins for address 1,2,3,4,5,6,7,8 (A0-A7) are left open. The programmed data is transmitted together with the header bits via IR transmission upon the receipt of a trigger signal. HT12A provides 38 kHz carrier for infrared systems. So, the data bits of HT12A are transmitted with a 38kHz carrier for IR remote controller flexibility. From the output pin (Dout), the encoder data output is serially transmitted. TSAL 7300 is the high power Infrared emitting Diode being used.

![Fig.4 Remote Panel Schematic Diagram.](image)

In fig.5. The HT12D, provides 4 latch type data pins whose data remain unchanged until new data are received. Now, this 4-bit data is sent to the microcontroller 8051 Port1. Later, the microcontroller will send programmed data bits to the motor controller L239 from Port 2 which is acting as output port here. The power supply includes the transformer and rectifier. In the schematic diagram of bed control (including motor control) has three motor controllers L239 is shown fig.6. Opto-coupler isolation is done to avoid issues of varying power supply. The DC geared motor being used requires 12 V supply while the other components require a 5V supply. Each motor controller has two outputs as shown. For L239, when an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high impedance state. When a 4-bit data is received from the microcontroller 8051 to the motor controller in specific, it gets activated and the associated motor would get into action, thus changing the position of the OT table. TSOP 1738 miniaturised receiver for the Infrared systems.

![Fig.5 Bed Control Schematic Diagram.](image)

II. Microcontroller, Encoder, Decoder, Motor control, DC Motor, Cam and Bevel Gears

A. Microcontroller

The AT89C52 is a low-power, high-performance CMOS 8-bit microcomputer with 8K bytes of Flash programmable and erasable read only memory (PEROM) is shown in fig.7. The device is manufactured using Atmel’s high-density non volatile memory
technology and is compatible with the industry-standard 80C51 and 80C52 instruction set and pin out. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with Flash on a monolithic chip, the Atmel AT89C52 is a powerful microcomputer which provides a highly-flexible and cost-effective solution to many embedded control applications.

The AT89C52 provides the following standard features: 8K bytes of Flash, 256 bytes of RAM, 32 I/O lines, three 16-bit timer/counters, a six-vector two-level interrupt architecture, a full-duplex serial port, on-chip oscillator, and clock circuitry. In addition, the AT89C52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next hardware reset.

Port 0 is an 8-bit open drain bi-directional I/O port. As an output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high impedance inputs. Port 0 can also be configured to be the multiplexed low order address/data bus during accesses to external program and data memory. Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups.

Port 1 also receives the low-order address bytes during Flash programming and verification. Port 2 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs. When 1s are written to Port 2 pins, they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (IIL) because of the internal pull-ups. Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that uses 16-bit addresses (MOVX @ DPTR). In this application, Port 2 uses strong internal pull-ups when emitting 1s. During accesses to external data memory that uses 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function Register. Port 2 also receives the high-order address bits and some control signals during Flash programming and verification.

Port 3 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins, they are pulled high by the internal pull-ups and can be used as inputs.

2.2 Encoder

These encoders are a series of CMOS LSIs for remote control system applications. They are capable of encoding information which consists of N address bits and 12N data bits. Each address/data input can be set to one of the two logic states. The programmed addresses/data are transmitted together with the header bits via an RF or an infrared transmission medium upon receipt of a trigger signal. The capability to select a TE trigger on the HT12E or a DATA trigger on the HT12A further enhances the application flexibility of the HTT12E series of encoders. The HT12A additionally provides a 38 kHz carrier for infrared systems (fig.8).

A0-A7: Input pins for address A0~A7 setting. These pins can be externally set to VSS or left open (fig.9).
AD8-AD11: Input pins for address/data AD8~AD11 setting. These pins can be externally set to VSS or left open.
D8-D11: Input pins for data D8~D11 setting and transmission enable, active low. These pins can be externally set to VSS or left open.
DOUT: Encoder data serial transmission output.
L/MB: Latch/Momentary transmission format selection pin.
Latch: Floating or VDD

2.3 Decoder

These decoders are a series of CMOS LSIs for remote control system applications is shown in fig.10. They are paired with Holtek_s 212 series of encoders (refer to the encoder/decoder cross reference table). For proper operation, a pair of encoder/decoder with the same number of addresses and data format should be chosen. The decoders receive serial addresses and data from a programmed 212 series of encoders that are transmitted by a carrier using an RF or an IR transmission medium. They compare the serial input data three times continuously with their local addresses. If no error or unmatched codes are found, the input data codes are decoded and then transferred to the output pins. The VT pin also goes high to indicate a valid transmission. These decoders are capable of decoding information that consist of N bits of address and 12_N bits of data. Of this series, the HT12D is arranged to provide 8 address bits and 4 data bits, and HT12F is used to decode 12 bits of address information.

Pin Description:

- **A0-A7**: Input pins for address A0~A7 setting. These pins can be externally set to VSS or left open.
- **D8-D11**: Output data pins, power-on state is low. **DIN**: Serial data input pin. **VT**: Valid transmission, active high.

2.4 L239D Motor control

The L293 and L293D are quadruple high-current half-H drivers are shown in fig.12. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications. A VCC1 terminal, separate from VCC2, is provided for the logic inputs to minimize device power dissipation. The L293 and L293D are characterized for operation from 0°C to 70°C (fig.13).
2.5 DC Motor

The DC motor has two basic parts: the rotating part that is called the armature, and the stationary part that includes coils of wire called the field coils. The stationary part is also called the stator. The armature is made of coils of wire wrapped around the core, and the core has an extended shaft that rotates on bearings. You should also notice that the ends of each coil of wire on the armature are terminated at one end of the armature. The termination points are called the commutator, and this is where the brushes make electrical contact to bring electrical current from the stationary part to the rotating part of the machine.

2.6 Cam

A cam is a rotating or sliding piece in a mechanical linkage used especially in transforming rotary motion into linear motion or vice-versa. It is often a part of a rotating wheel (e.g. an eccentric wheel) or shaft (e.g. a cylinder with an irregular shape) that strikes a lever at one or more points on its circular path. The cam can be a simple tooth, as is used to deliver pulses of power to a steam hammer, for example, or an eccentric disc or other shape that produces a smooth reciprocating (back and forth) motion in the follower, which is a lever making contact with the cam as shown in fig.16.

Fig.12 Pin configuration of L239

Fig.13 Block diagram of L239D

Table.1 Function Table for each Driver.

<table>
<thead>
<tr>
<th>INPUTS†</th>
<th>OUTPUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>EN</td>
</tr>
<tr>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>L</td>
<td>L</td>
</tr>
<tr>
<td>X</td>
<td></td>
</tr>
</tbody>
</table>

† In the thermal shutdown mode, the output is in the high impedance state, regardless of the input levels.

H = high level, L = low level, X = irrelevant, Z = high impedance (off)

Fig.14 Logic diagram of L239D

This chip contains 4 enable pins. Each enable pin corresponds to 2 inputs. Based on the input value given, the device connected to this IC works accordingly.

Fig.15 Stator

Fig.16 A Mechanical CAM.

Specifications of cam
- Base circle diameter: 20mm
- Prime circle diameter: 50mm
- Material: Plastic

2.7 Bevel gears

Bevel gears are gears where the axes of the two shafts intersect and the tooth-bearing faces of the gears themselves are conically shaped shown in fig.17. Bevel gears are most often mounted on shafts that are 90 degrees apart, but can be designed to work at other angles as well. The pitch surface of bevel gears is a cone.

III. Results And Discussions
3.1 Modelling the Bed

The model of the bed was created using CATIA Software. The following are the screenshots that were obtained during the modeling (From fig.18-23).

The required software tools are discussed with firmware implementation of the model as follows.

3.2 Software tools

The following software tools required for running the table.

- Keil µvision3
- Sprint Layout
- OrCAD

A compiler for a high level language helps to reduce production time. To program the AT8051
microcontroller the Keil µvision3 is used. The programming is done strictly in the embedded C language. Keil µvision3 is a suite of executable, open source software development tools for the microcontrollers hosted on the Windows platform.

The compilation of the C program converts it into machine language language file (.hex). This is the only language the microcontroller will understand because it contains the original program code converted into a hexadecimal format. During this step there are some warnings about some eventual errors in the program. If there are no errors and warnings then run the program, the system performs all the required tasks and behaves as expected the software developed. If not, the whole procedure will have to be repeated again.

One of the difficulties of programming microcontrollers is the limited amount of resources the programmer has to deal with. In personal computers, resources such as RAM and processing speed are basically limitless when compared to microcontrollers. In contrast, the code on microcontrollers should be as low on resources as possible.

3.2.1 Keil Software
Keil compiler is software used where the machine language code is written and compiled. After compilation, the machine source code is converted into hex code which is to be dumped into the microcontroller for further processing. Keil compiler also supports C language code as shown in fig.24.

3.2.2 OrCAD Capture Software
OrCAD Capture is the core schematic entry program in the three program suite by Cadance called OrCAD.

This suite also consists of Pspice (circuit simulation software) and Layout (circuit board layout) packages is shown in fig.25. All applications begin with Capture.

3.2.3 Sprint Layout
With Sprint-Layout can be design the PCB’s quick and easy. There is no unnecessary “ballast” which makes it difficult to keep the overview or which makes the usage almost impossible. Because of the logical and understandable structure of Sprint-Layout the usage is very easy to learn. So finally, it can concentrate to the essential thing: Designing and optimizing your PCB-layouts. Sprint-Layout offers all needed functions to design the own layouts. There is an extensive library with all common components included.

For manufacturing the PCB’s by hand, there is an excellent printout-procedure with many options available. To produce professional boards, there are many PCB-manufacturer, which accept Sprint-Layout files. Sprint-Layout is also able to create HPGL files for isolation-milling. The new version 5.0 includes many new features and improvements, which makes the software more comfortable. As always, take very much care of an user-friendly operation. Of course the new version 5.0 is fully compatible to all older versions of Sprint-Layout. With the free viewer-software for Sprint-Layout it is possible for everybody to view or print your layouts. Sprint-Layout is equipped with tools to draw pads, tracks, copper areas and labels shown in fig.26. Just select the corresponding mode and place the elements. All parameter like track-width, pad-size, etc. are always visible at a glance, and can be edited every time. The active grid-capture lets you easily place your elements exactly. One can edit existing layout-elements very easy. For example if adjust the width of a track, it will see the result immediately on the layout. Additional functions like copy, move, rotate, mirror, etc. are self evident.

IV. Merits and Applications
4.1 Merits
- Wireless controlling of the OT table. It is convenient over the usage of wired remotes.
Its compact size is an advantage over bulky hydraulic operated beds.
- As IR is used as medium of communication, it is safe. IR signals cannot penetrate through walls and are local to the Operation theatre.
- The equipment is conveniently operated by both the patient and the doctor.
- The power consumption is nominal.

4.2 Applications
- Operation table with wireless remote can be used in Medical industry to perform several surgeries.
- Shifting the patient from one table to another is easy.

The performance of the system is efficient. Continuously reading the inputs from the remote control and change the position of the OT table as per the specified command is the main job carried out by microcontroller in this project. The mechanism is controlled by the microcontroller.

Final specifications of multi axis Remote controlled bed

- D.O.F : 4
- Height : 32 cm (max); 27cm (min)
- Angle of tilt : head=45˚; leg=35˚; Bed=20˚
- Temperature sensor range : 90-105°F

V. Conclusions
- The implementation of Wireless Remote Control System for Multi-Axis Operational Theatre Bed Control System using Microcontroller is done successfully.
- The communication is properly done without any interference between the modules in the design. Design is done to meet all the specification and requirements.
- Software tool namely Keil µ-Vision Simulator has been used to dump the source code into the microcontroller, OrCAD for the schematic diagram, Sprint Layout for the PCB design have been used to develop the working module.
- It can be concluded that the design implemented in the present work provide portability, flexibility and the data transmission is also done with low power consumption.

VI. Future Scope
- The implementation of Wireless Remote Control System for Multi-Axis Operational Theatre Bed Control System using Microcontroller can be operated using with the help of wireless equipment RF communication.
- Other advanced control methods like Bluetooth connectivity, motion sensor enabled capabilities and voice control can be adopted.
- Feed-back control system can be used to control the tilt of the bed.
- Other sensors like pulse rate sensor, devices to measure blood pressure can be incorporated.

VII. References