Design and Fabrication of Driverless Remote Operated Forklift

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Abstract- **The main objective of our project is to make a mechanical prototype module with square metal pipes, the structure looks like a rectangular box & the vertical moving mechanism that contains metal forks is assembled over the structure at front side. Since it operates through a remote, it doesn't contain any steering mechanism. The entire vehicle is designed to drive through four wheels &motors are used to drive all the four wheels directly. All the motors are driven through a single 'H' bridge DC motor drive package. The DC Motors are having reduction gear mechanism internally, there by speed is reduced and torque is increased. There is also a lead screw mechanism which is used for linear mechanism of fork for load lifting work which is driven by side shaft motor.**

Index Terms- Autonomous forklift, DC motors, RF transceiver.

I. INTRODUCTION

The forklift can be defined as a device capable of lifting heavy loads. A forklift is a vehicle similar to a small truck that has two metal forks on the front used to lift load. The forklift operator drives the forklift forward until the forks push under the load. Since it operates through a remote, it doesn't contain any steering mechanism. The entire vehicle is designed to drive through four wheels &motors are used to drive all the four wheels directly. All the motors are driven through a single 'H' bridge DC motor drive package. The DC Motors are having reduction gear mechanism internally, there by speed is reduced and torque is increased. There is also a lead screw mechanism which is used for linear mechanism of fort for load lifting work which is driven by side shaft motor.

The mainly is about designing and fabricating forklift which is operated by wireless controlled. The lift and movement system of the forklift will be provided by miniature electric-powered motor. This forklift can move forward, backward, turning right and left depend on the signal from wireless module. The objective of this project is to design the forklift which includes the physical structure, electronic circuit, control and operating system. The research on this field has great functions and benefits and can be proceed in the future.

A. Aim and Objective

As we all know that in today's scenario we are moving towards the modernization. So through this project we want to modify the present model of the forklift. Our aim is based on the present technology of forklift we are going to design and develop a model using microcontroller for lifting the object up to its capacity level, controlled wirelessly. Industrial lift trucks are used for handling materials, parts, products, tools, equipment, supplies and maintenance items. Forklifts are efficient for material handling because they are self-propelled, maneuverable and require only one operator to lift, transport, and stack or unstack the material. Forklifts may be used for indoor or outdoor use depending on their size, tires and load capacities.

B. Scope Of The Project

The forklift prototype is a four-wheeled that has the ability to follow the direction guided by the operator. There are four wheels including two driving wheels controlled by two motors and two free wheels in front that is able to rotate 360°. With four wheels, both driving wheels are always in contact with the surface. This project consists of four main stages, which are theoretical design, mechanical fabrication, electronic hardware design.

II. WORK ACTIVITIES OF FORK LIFT TRUCK

Forklift trucks are vehicles designed to move and stack heavy or bulky goods. They are mainly used in warehouses, stockyards and other storage areas. Forklift trucks are highly mobile with a very small turning circle which allows them to move easily in confined spaces.

The driver must fit these forks into the pallets on which goods are stored. The operator then uses the lead screw to lift the pallet, takes it to where it is needed and sets it down. Some goods, such as bricks, can be moved by fork-lift trucks without the need for pallets. They are stacked in bales with spaces for the forks. Some trucks are fitted with small computer display panels that direct the operator where to place goods in the warehouse.

Figure.1   Project Model of forklift

III.   FEATURES OF FORK LIFT

- *Capacity:*- Usually forklifts start at around 600 kg load lifting capacity and go up to52,000 kg, which is a staggering 52 tons. Most forklifts are rated for less than 3 tons .However, weight is not as straightforward as it may seem. The size of the load will also impact the capacity. Weight capacity is usually based on a 600 mm (24 inch) load center, although this can vary. This means that the distance from the center of the load the edges can be no more than 600 mm. If the load is bigger and/or longer, the truck will not be able to lift as much weight.

- *Fork lift safety awareness:*-In every wholesaler-distributor operation, stacks, bundles and rolls of raw material and finished products of various shapes, sizes and weights must be moved. Excessive and inefficient material handling affects the productivity and profits. And manual material handling may be dangerous. Efficient material handling systems and safe operation of material handling equipment such as powered industrial trucks are the solution.

IV.   MECHANICAL ACTUATION SECTION

The mechanical system is considered as motion converter, this can be created by implementing electro-mechanical techniques. The concept is to transform the motion from one form to some other required form by using suitable mechanical & electrical devices. In this project work the technique of transform the rotational motion in to linear motion is implemented. For this purpose three DC motors are used to create motion in the mechanism that functions as forklift. As the machine is designed as prototype module, lowest rating motors are used to drive the mechanism.

Only speed and operating voltage is specified, as per this data these motors are designed to operate at 12V DC & the motor speed is 30 RPM. These motors driving capacity is tested practically, in our test we came to know that each motor can drive in independent load of maximum 5Kg. there by according to this driving capacity, one small forklift vehicle is designed for the demo purpose.The vertical moving mechanism is coupled with motor shaft.. The vertical moving mechanism is designed with ball bearing type smooth sliding channels; these channels are lubricated to avoid friction in the movements. There by the forks welded with the vertical moving mechanism are raised and lowered according to the command signals received from the receiver. The forklift vehicle chassis is driven through four DC motors; all the four wheels are directly coupled with motor shafts. Two increases the torque left side motors and right side two motors are connected in parallel, when the vehicle is moving in forward direction, the right side motors will rotate in clock wise, whereas the left side motors rotate in anti-clock wise. This phenomenon will be exactly reversed while traveling the vehicle in reverse direction. During right turn, both left motors & both right motors will rotate in anti-clock wise.

Similarly to take left turn, all the four motors should rotate in clock wise.

V.   MECHANICAL PARTS SPECIFICATIONS

Base
- Area of chassis: 37*37cm
- Height of chassis from ground floor: 10cm
- Thickness of Base: 3cm

Slider
- Height of slider: 50cm
- Width of slider: 3cm
- Thickness of slider: 1.3cm
- Size of slider: 13*10cm
- Distance between slider: 18cm

Motors Specifications:

Figure.2   DC motor

- Speed: 30 rpm
- Capacity: 12V & 1Amp
- Number Of Motor Used: 3
- 18000 RPM base motor
- Shaft : 6mm
- Gearbox diameter : 37 mm.
- Motor Diameter : 28.5 mm
- Length : 63 mm without shaft
- Shaft length : 15mm
- Weight : 8kg
- No-load current = 800 mA(Max),
- Load current = upto 9.5 A(Max)

Lead Screw
- Type of Lead Screw used: Single Start
- Pitch Of The Screw =3mm
- Diameter of Screw: 1.2cm
- Height of lead screw:16cm

Pallet
- Area of pallet:10*10cm
- Load: 5 to 8kg

Wheels
- Diameter of wheels:9cm
- Width of wheels:3.5cm

Battery:

Figure.3   Battery

Voltage: 12V & 7.2amp
 Small battery to operate remote:
Specification:9V&1.2Amp

VI.   DESIGN OF LEAD SCREW

P=Pitch Of The Screw =3mm
d=Mean Diameter Of Screw = 12mm
α=Helix Angle   =4.59°

P=Effort Applied At The Circumference Of The Screw To Lift The Load=6.37N

W=Load To Be Lifted= 5KG =5×9.81=49.05N

μ=0.05=Coefficient Of Friction

φ=Friction Angle=2.86°

Figure.4   Lead Screw

P=w× tan (α+φ) =49.05×tan (4.59+2 .86)=6.37N

Torque For Overcome Friction Between Screw And Nut

T_1 = (P× d/2) =6.37×(12/2)= 38.22N-rnm

M.A.= W/P =49.05/6.37=7.7

Torque Required Lowering The Load

P=w× tan (α-φ) =49 .05×tan (4.54-2 .86) =1.4386N

Torque For Overcome Friction Between The Screw and Nut

T_1=P× (d/2) =1.4386× (12/2) =8.63N-mm

Efficiency : η= M.A. /V.R. =tan α/ tan (α+φ)

η=61%

Maximum Efficiency:

$η_{max}$=(1-sinφ)/(1 +sinφ) =(1-sin4.54)/ (1 +sin4.54)

=85.33%

For Self Locking: φ < α

VII.   ELECTRONICS DESCRIPTION

A. Electronic Circuit Design

All circuit involved and the connections between devices will be explained. The electronic part is divided into four parts consists of power supply circuit, main circuit, motor driver circuit and RF module. Power supply circuit includes of 5 volts and 6 volts voltage regulator. The main circuit consists of PIC16F877A microcontroller circuit and its peripherals. Meanwhile the interface circuit consists of the motor driver circuit and RF module. Those electronic circuits part are done on the donut board. As overall, there are four part of electronic circuit total.
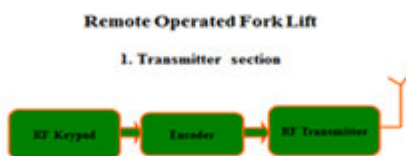
B. Principle operation of remote
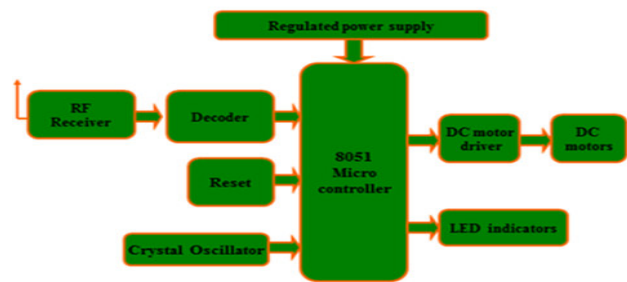

Figure.5   Transmitter Section

Figure.6   Receiver Section

C. RF Remote technology

Radio waves belong to a particular type of waves called electromagnetic waves, a form of energy resulting from a combination of electrical and magnetic effects of rapidly changing electric currents. Although not visible to the eye, radio waves travel with the velocity of light waves which is 1, 86,000miles per second. In fact, both light waves and radio waves are electromagnetic waves. Sound also travels in the form of waves but sound waves are not electromagnetic waves. Compared to electromagnetic waves, sound waves travel at a much lower speed of 1100 feet per second.

Radio wave in one second is called the frequency of the radio wave. The unit of frequency is hertz, which is one cycle per second.

Every communication system is allocated with a fixed frequency for operation which is required to be maintained constant within prescribed limits to avoid interference with neighboring stations. Waves are to carry a message or information, some feature of the radio wave must be varied in accordance with the information to be communicated. The process by which the information is superimposed on the carrier is called modulation. In the case of radio broadcasts the information or the message generally consists of low frequencies in the range of 20Hz to 20,000Hz. These low frequencies are called audio frequencies

When the receiver is synchronized with the transmitter it can be said as the receiver is tuned with the transmitter, if the receiver is tuned perfectly then the communication link will be established.

D. RF transmitter and RF receiver

- RF is an electronic device which uses radio waves for transmitting the signal.
- RF receiver is an electronic device which receives the data present in the radio waves and filters out unwanted data.
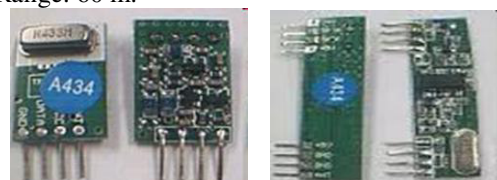- Transmission channel: 434 MHz.
- Range: 60 m.

Figure.7   RF transmitter & RF receiver

E. H – Bridge

The motor driving circuit is designed with L293D chip; this is popularly known as 'H' bridge device generally used to drive the low power DC motors. The current flowing through each driver circuit is restricted to 600 amp& it can with stand up to a peak current of 1.2amps.This chip is having two drive circuits internally; therefore it can drive two DC motors simultaneously. As two motors are connected in parallel, single chip can drive four motors comfortably.This device is built in with four channel drivers, there by both motors can be rotated in both directions.

The DC motors used to drive the wheels will not consume more than 200 milliamps at full load, two motors together consumes a maximum power of 400 milliamps, as the each drive circuit is capable of supply 600 milliamps comfortably.

F. Manual Operation Keys

In addition to the remote controlled keys, the forklift is equipped with 4 manual keysBy activating these keys manually, all the movements can be created in the forklift. All these 4 keys are directly interfaced with microcontroller at input side, one end of all the keys are shorted together and connected to the ground. When any key is depressed active low signal is generated for the controller, based on this signal the controller drives the DC motors through 'H' bridge.

TABLE I. OPERATION OF REMOTE SWITCHES

S. No	Switch	Operation Mode
1	Only S1	Right Turn
2	Only S2	Left Turn
3	Only S3	Forward Direction
4	Only S4	Reverse Direction
5	S2 + S4	Upward Direction
6	S1 + S3	Downward Direction

G. Microcontroller

The controller used here is belongs to 8051 family architecture & often it is referred to as MCS-51. This microcontroller is having an 8-bit data bus. In this family some of the controllers are capable of addressing 64K of program memory and a separate 64K of data memory. The 8051 has 4K of code memory implemented as on-chip Read Only Memory (ROM). The 8051 has 128 bytes of internal Random Access Memory.
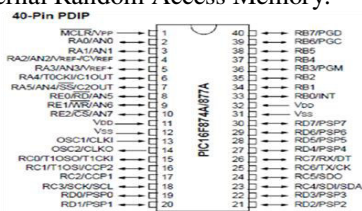

Figure.8   Pin diagram

As stated, the 8051 can address 64K of external data memory and 64K of external program memory. These may be separate blocks of memory, so that up to 128K of memory can be attached to the microcontroller. Encoder is used to generate the digital data which need to be transmitted.

TABLE II. SPECIFICATION OF MICROCONTROLLER

Key Features	PIC16F877A
Operating Frequency	DC – 20 MHz
RESETS (and Delays)	POR, BOR (PWRT, OST)
FLASH Program Memory (14-bit words)	8K
Data Memory	368
EEPROM Data Memory	256
Interrupts	15
I/O Ports	Ports A,B,C,D,E
Timers	3
Capture/Compare/PWM Modules	2
Serial Communications	MSSP, USART
Parallel Communications	PSP
10-bit Analog-to-Digital Module	8 input channels
Analog Comparators	2
Instruction Set	35 Instruction
Packages	40-pin PDIP, 44-pin PLCC, 44-pin QFP

H. Encoder
- The encoder used in the project is HT12E.
- This encoder has 8-address lines and 4-data lines.

Figure.9   Encoder

I. Decoder
- Decoder is used to decode the required data from the received data.
- The decoder used in the project is HT12D
- This decoder has 8-address lines and 4-data lines

Figure.10   Decoder

VIII.   CONCLUSION

The project work "Remote operated forklift" is aimed to control through wireless communication network designed with RF modules. The main advantage of using this technology is to increase the safety of operator by operating the forklift from certain distance. This increases the efficiency of the productivity, because human errors due to the poor visibility can be minimized. The system is designed and developed successfully, for the demonstration purpose prototype module (mini module) is constructed & results are found to be satisfactorily.

Most of all human safety is a major concern's by using a remote controlled forklift. We can use our human brain but the hands and legs of a robot, and thereby

nullifying the chances of accident. Our project is just a prototype, in which we have used any electronic micro-controller in its IC.

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