IJARCCE

ISSN (Online) 2278-1021
ISSN (Print) 2319 5940

*International Journal of Advanced Research in Computer and Communication Engineering*
*Vol. 5, Issue 3, March 2016*

# PLC based Control of Motors in Cranes using Remote Control

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**Abstract:** EOT (electrically overhead trolley) or Crane is used to lift and move materials in industries. For efficient operation, an induction motor with VVVFD in industrial applications. The relay logic in crane control is implemented using PLC .This method is controlled by using remote system.

**Keywords**: Variable Voltage Variable Frequency Drive (VVVFD), Programmable Logic Controller (PLC), Human Machine Interface (HMI), Radio Frequency (RF) & Peripheral Interface Controller (PIC).

## I. INTRODUCTION

The conventional method uses slip ring induction motors with resistance box .In order to overcome the losses caused by resistance box, a VVVFD is employed which provides wide range of speed control with dynamic braking in industrial applications. But in this paper PIC16F877A microcontroller which employs the in-built PWM technique for speed control in DC motor is used. In a traditional industrial crane control system, all control devices are wired directly to each other according to how the system is supposed to operate. Here human is the main to control the crane & that passes through large drawbacks such as more wiring work, appears large mechanical faults & difficulties in troubleshooting & repair work .Due to these drawbacks industrial production decreases largely. In order to remove irregularity of relays and wiring issue we prefer PLC to control and monitor the operation of crane in the industry**.**

PLC is used to eliminate the large cost involved in changing complicated relay based machine control systems. These relay based systems were very flexible; their configuration and capability and structure or complete replacement of relay based system was necessary every time when the production requirements Changed and control sequences had to be modified. The PLC is packaged and designed for extended temperature ranges, dirty or dusty conditions, immunity to electrical noise, and is mechanically more rugged and resistant to vibration and impact. By implementing this, we decreases man power, thus increase in production of the industry.

VVVFD is variable voltage variable frequency drive. It has 3 sections. Namely a rectifier which converts ac to dc, the L and C component removes ripples in the waveform. Then an inverter converts dc to ac.PWM drives use various types of power transistors like IGBTs, and GTOs (gate turn-off—SCRs). These semiconductors provide the advantages of PWM technology without the expense of commutation circuits. Commutation circuits are required to turn off the SCRs once they start conducting. One of the major difference is that the actual voltage output of the inverter itself. The DC bus voltage is fixed and it approximately equals to the RMS value of the drive input voltage, By means of chopping or modulating the DC bus voltage, which results in the average voltage (output voltage) to be increased or decreased. By the length of time the power semiconductors actually conduct, the output voltage value is controlled. The longer the on time for the semiconductors, the higher is the output voltage. The longer the off times occur in the process, the lower the frequency output. Thus the inverter accomplishes both variable voltage and frequency.

$$\phi(\text{flux}) \alpha E/F \quad .....(1)$$

By maintaining the above ratio constant, the flux is maintained constant, so that the core saturation is avoided. The equation (1) should be maintained constant under all the conditions of operation, provided that the stator leakage reactance is small. In order to maintain high torque throughout the control range, the air gap flux should be Constant.i.e E/F should be constant. At maximum frequency the maximum torque remains almost the same. At lower frequency air gap flux also decreases, therefore stator voltage drop becomes an important factor and maximum torque decreases.

At higher operating frequency, the efficiency also increases/f control is preferred over the previous resistance box due to various advantages provided by it such as to maintain maximum torque at variable speed and frequency.

It provides high efficiency .wide range of speed (i.e. speed control and breaking operations are available from zero speed to above base speed).during transients the operation can be carried out at maximum torque with reduced current giving good dynamic response.

The copper losses are low, and the efficiency and power factor are high as the operations is restricted between synchronous speed and maximum torque point at all frequency. The drop in speed from no load to full load is small.

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## II.PLC

A PLC is a small computer used for automation of real-world processes. A digital electronic device that uses a programmable memory to store instruction and to implement function such as logic, sequencing, timing, counting and arithmetic in order to control machines and process.

The term logic is use primarily concerned with implementing logic and switching operations .Input devices e.g. switches, and output devices e.g. motors, being controlled are connected to the PLC and then the controller monitors the inputs and outputs according to this program stored in the PLC by the operator and so controls the machine or process.

The PLC can be implemented using two logics, namely ladder logic and fuzzy logic. The fuzzy logic implementation requires high expertise here ladder logic is implemented.

The PLC has 12 ports, in which 8 ports are initialised for inputs and 4 ports are initialised for outputs. In general 108 rungs can be drawn, in this ladder diagram 16 rungs are used.

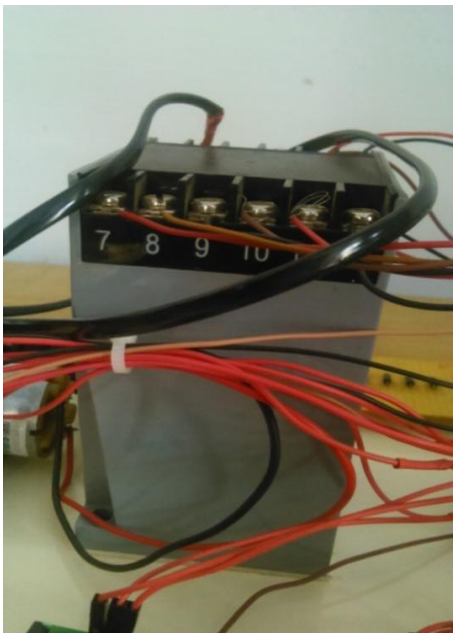

Fig 1.PLC

RF receiver and the motors are connected in the input and output module of PLC.HMI is connected with PLC through the RS232 interface. Supply voltage given to the PLC is 24V.

The six switches are connected at the transmitter module to control the movement of the motors.

The data transmitted from the antenna travels as electromagnetic waves and reach the receiver side. According to the input from the transmitter side, the receiver side will decode the data using decoder and the crane will operate to the respective signals received.

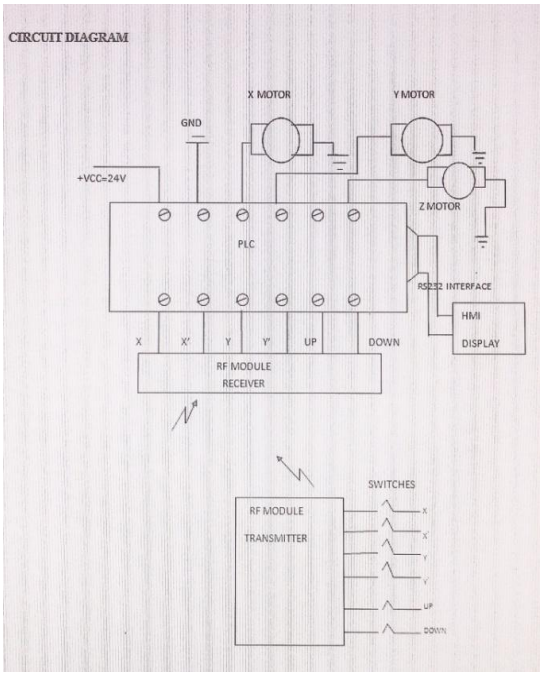


Fig 2.Block Diagram

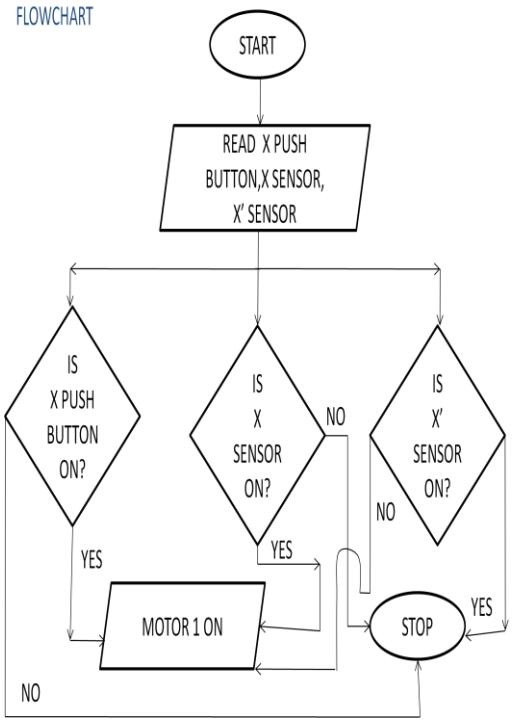


Fig3.Flow Chart

From FIG.3,The motor starts running when the inputs x push button for left side movement of long travel in crane , the corresponding sensor X is activated and the sensor X' for right side movement detection is in deactivated state. Similarly, for the right side movement in long travel, the inputs are X' push button, X'sensor to be in true condition and X sensor to be in false condition then the motor runs. Otherwise if the above stated conditions are reversed then the motor stops. Similar operations are carried out for cross travel and hoist travel of crane.


DOI 10.17148/IJARCCE.2016.5331

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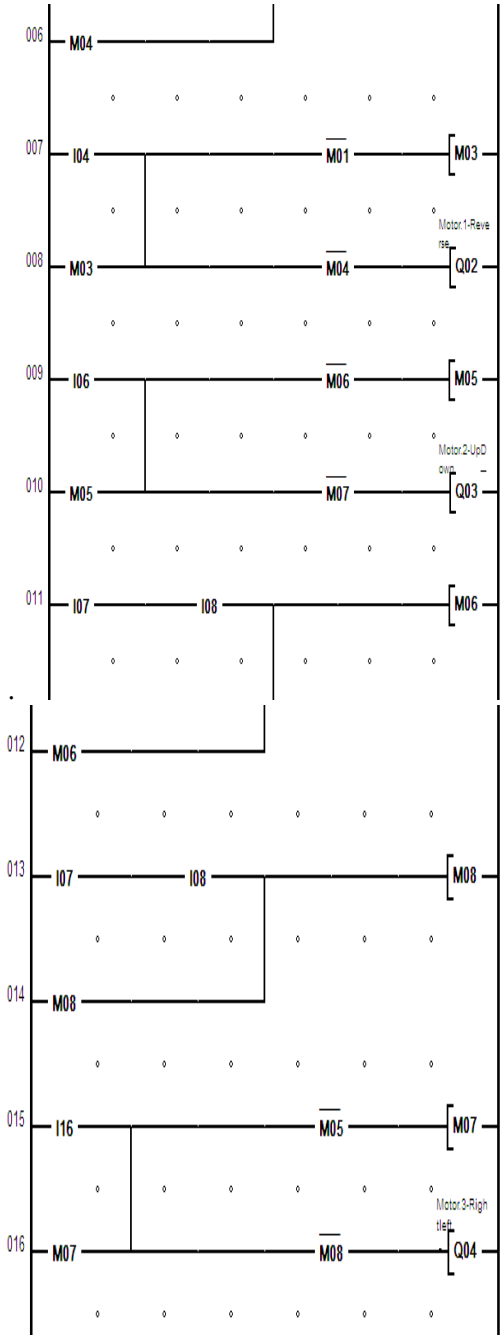


Fig4.Ladder Diagram

From fig4, we can infer that, when the input 1 is on, motor runs in forward direction. When the input 2 is on, sensors will get turned on. The sensors will be in on state for both forward and reverse direction. When the input 3 is on, the sensor will sense and the motor which is rotating in forward direction gets stopped. The motor runs in reverse direction if the input 4 is on. When the input 5 is on, the sensor senses the obstacle and stops the motor. The input 6 is for up and down movement of motor. When the input 7 is on, the initial process is on for left and right movement and the sensor is in on state for up and down movement.fot turning off rotation in up and down direction, input 8 is turned on. When input 16 is on, right and left movement of motor is turned on. The ladder logic will execute continuously.

## III.REMOTE CONTROL

The RF module operates at Radio Frequency. The corresponding frequency range varies between 30 kHz & 300 GHz. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 312MHz .The signals through RF can travel through larger distances making it suitable for long range applications.

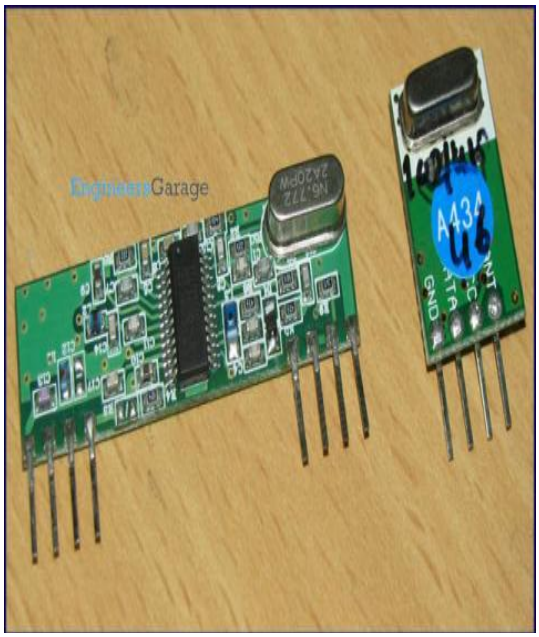


Fig5.RF Module

Also, RF signals can travel even when there is an obstruction between transmitter & receiver. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna. The RF module is often used along with a pair of encoder/decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder. HT12E-HT12D, HT640-HT648, etc. are some commonly used encoder/decoder pair ICs.The HT12E-HT12D pair is used in this project.

HT12E is an encoder integrated circuit of $2^{12}$ series of encoders. They are paired with $2^{12}$ series of decoders for use in remote control system applications. It is mainly used in interfacing RF and infrared circuits. The chosen pair of encoder/decoder should have same number of addresses and data format.

Simply put, HT12E converts the parallel inputs into serial output. It encodes the 12 bit parallel data into serial for transmission through an RF transmitter. These 12 bits are divided into 8 address bits and 4 data bits.

HT12E has a transmission enable pin which is active low. When a trigger signal is received on TE Pin, the programmed addresses/data are transmitted together with the header bits via an RF or an infrared transmission medium. HT12E begins a 4-word transmission cycle upon receipt of a transmission enable. This cycle is repeated as long as TE is kept low. As soon as TE returns to high, the encoder output completes its final cycle and then stops.


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HT12D is a decoder integrated circuit that belongs to $2^{12}$ series of decoders. This series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system etc. It is mainly provided to interface RF and infrared circuits. They are paired with $2^{12}$ series of encoders. The chosen pair of encoder/decoder should have same number of addresses and data format.

In simple terms, HT12D converts the serial input into parallel outputs. It decodes the serial addresses and data received by, say, an RF receiver, into parallel data and sends them to output data pins. The serial input data is compared with the local addresses three times continuously. The input data code is decoded when no error or unmatched codes are found. A valid transmission in indicated by a high signal at VT pin.

HT12D is capable of decoding 12 bits, of which 8 are address bits and 4 are data bits. The data on 4 bit latch type output pins remain unchanged until new is received.

Fig6. Remote control

The modulating frequency is 312MHz.there are totally 9 switches to perform start ,stop, front to back, back to front ,left to right, right to left movement operation.

A LCD display is used for display purpose. A16x2 LCD can display 16 characters per line and there are 2 such lines. In this LCD, each character is displayed in 5x7 pixel matrix. This LCD has two registers, Command and Data.The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD. The data is the ASCII value of the character to be displayed on the LCD.

## IV. SPEED CONTROL USING PIC

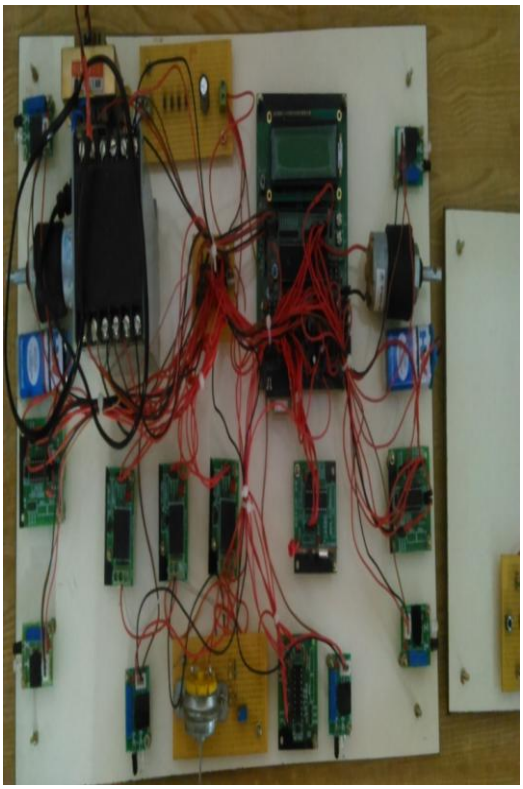

Fig7.Speed Control Of Motor Using Pic

The speed control of dc motor is employed using pulse width modulation technique in which the amount of power delivered to an electronic load using an on-off signal is controlled. Fraction of period for which the signal is on is called as duty cycle. The signals average dc value is varied by varying the duty cycle. In this paper, the PWM signal is generated using PIC 16F877A microcontroller. PIC16F877A has a build-in hardware called capture /compare /PWM (ccp) module, to generate a PWM signal.

$$PR2 = \left[\frac{F_{osc}}{F_{PWM}*4*N}\right] - 1 = \left[\frac{20*10^{6}}{20*10^{3}*4*1}\right] - 1 = 249$$

Here, the PWM frequency is 20khz.There are 3 registers. The period register stores the full time period value. The duty cycle register stores the duty cycle value depending on our need (100% or 75% or 50%). If a particular value of duty cycle is given in percentage, then that much percentage of the time period gives the PWM mode value which is stored in control register.

Limit switches are present to avoid crane from colliding with another crane. There are totally 6 limit switches (sensors) that is 2 limit switches for each DC motor. Here variable speed levels are shown only for up and down movement of crane.

The motor speed for long and cross travel of crane is constant. The various speed levels are low, medium and high .so for each speed level separate relay is used.


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Depending upon the input, the corresponding relay gets energised and makes the motor to run at specific speed. When the input is given as back to front through switches, the motor runs in forward direction.Incase the motor has to stopped then stop switch can be pressed .in order to avoid crossing the limit, limit switches are provided for all motors at both extremes.

If the crane moves forward and reaches the limit, the corresponding sensor gets activated and stops the motor. When the crane moves front t to back and reaches the limit then that specific sensor gets activated and stops the motor. Similar operation is for left to right movement.

For down to up movement three speed levels are provided-low, medium, and high. Here, speed levels are not given for up to down movement as there is no need. When the input is given as high, then motor runs at high speed.

Here also limit switches are present to avoid collision. Similarly the motor runs at low or medium or high depending on the input.

## V.H-BRIDGE&MOTOR

An H bridge is an electronic circuit that enables a voltage to be applied across a load in either direction. These circuits are often used in robotics and other applications to allow DC motors to run forwards and backwards.

Most DC-to-AC converters (power inverters), most AC/AC converters, the DC-to-DC push–pull converter, most motor controllers, and many other kinds of power electronics use H bridges.

In particular, a bipolar stepper motor is almost invariably driven by a motor controller containing two H bridges.H-bridge is employed to obtain operation like hoist, cross travel and long travel in crane prototype. Separate DC motors are employed to achieve the above operations.

The relay rating is 12v.two gear motors and one ordinary motor is used. The gear motor rating is 60rpm,12V,0.5A whereas for the ordinary dc motor rating is 5V,0.3A.The gear motors are for front and back movement and for left and right movement.inorder to show the variable speed levels, ordinary dc motor is used for up and down movement.

In fig8, when the supply is given, the user gives inputs through push buttons namely left side movement, right side movement, front movement, back movement, down to up movement with three speed range from low, medium to high that is controlled through

PWM technique using a PIC microcontroller, then an up to down movement at full speed i.e. at high, then a stop button. As the required input is given, the transmitter transmits the signal to the receiver through an encoder decoder pair. And the corresponding relay gets energised and motors starts running. When the limit switch senses the object the motor is stopped. Similar operations are carried out for various inputs.

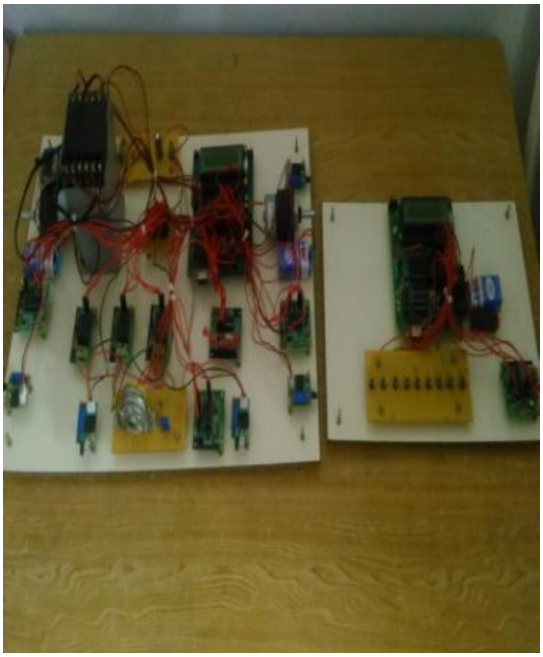

Fig8.Overall Prototype

## VI. CONCLUSION

A robust crane control system is designed by using PLC and operated using radio remote control. The speed control is achieved using PIC16F877A microcontroller with in-built PWM module. This control system will be of immense use in fabrication industries.With PLC, troubleshooting is made easy and the process becomes simple. Thus this method is user-friendly and can be implemented in process industries.

## ACKNOWLEDGMENT

We take this opportunity to express our deepest gratitude and thankful to all those who have helped us directly or indirectly towards the completion of this paper successfully.

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