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Design and Prototyping of a Safe Remote Control Unit for EOT Crane

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Abstract—*Industrial equipment, in the field of work should always be satisfying the basic need of safety in addition to its functioning. As the EOT cranes are used widely in the field of material handling in various manufacturing plants, they have to be carefully handled and operated. This particular project works on design and prototyping of modified remote control unit in EOT crane which will include a precise operation level and also a failsafe mechanism. This is proposed to be achieved with a proper data transmission reception and conditioning techniques. The speed control of induction motor is controlled by a technique of Variable Voltage Variable Frequency Source (VVVF).*

Keywords: *Eot crane, Speed control, RF remote, VVVF*

1. INTRODUCTION

An overhead crane, commonly called a bridge crane, is a type of crane found in industrial environments. An overhead crane consists of parallel runways with a traveling bridge spanning the gap. A hoist, the lifting component of a crane, travels along the bridge. If the bridge is rigidly supported on two or more legs running on a fixed rail at ground level, the crane is called a gantry or a goliath crane. Unlike mobile or construction cranes, overhead cranes are typically used for either manufacturing or maintenance applications, where efficiency or down time are critical factors. So to control these cranes so that they will operate at precise positions is a real need in the industrial field. This precision control of the EOT crane is to be achieved in this project by a proper implementation of the variable voltage variable frequency method. This project was an attempt to use a modified remote control unit and make it more reliable. The project achieved the design of a speed control system using a Variable Voltage Variable Frequency [1] Source and to create a unit with regulated and limited range of operation. Cranes are industrial machines that are mainly used for materials movements in construction sites, production halls, assembly lines, storage areas, power stations and similar places. Their design features vary widely according to their major operational specifications such as: type of motion of the crane structure, weight and type of the load, location of the crane, geometric features, operating regimes and environmental conditions. The crane bridge travels on top of rails mounted on a runway beam supported by either the building columns or columns specifically engineered for the crane. Top Running Cranes are the most common form of crane design where the crane loads are transmitted to the building columns or free standing structure. These cranes have an advantage of minimum headroom / maximum height of lift.

The AC operated EOT cranes will be generally using a slip ring induction motor. The rotor winding of the motor will be connected to a power resistance[1]. Speed control is done by changing the rotor resistance in different steps by power contactors. Reversing is done by changing the phase sequence of the stator supply through line contactors. Braking is achieved by plugging operation[3]. There will be a controller that will provide a full voltage excitation to stator and adjusts the speed of rotor by impedance variation.

This method hosts a big disadvantage of huge size and weight of controller which includes power resistance, contactors and time delay relay. This will need an extensive maintenance effort.

The range of operation for a remote control will play a very important role in safety of the plant's staff and equipment handling.[8] There will usually be a problem faced by many industries where there will sometimes be safety problem encountered where technical personal may operate the crane and handle the material from a very long and undesired distance level, as the remote will provide access that far[6]. The speed control module comprises of a RF controlled Variable Voltage Variable Frequency system[1]. This will enable us to control the motor speed by varying the feeding frequency to the stator[8]. This operation is controlled though a Nob to control the varying frequency.

The proposed system is derived from a theory of speed control by stator frequency control. This is a practically proved and industrial level tested principle. This particular system is going to make an attempt to bring this principle to remote control operated level. There has been already attempt made by few researchers to control speed of motors in this way and was successfully achieved. There are also few remote control units existing in the market and in research, each with a different set of operations and specifications. But this system will be of its own specifications as mentioned above and will take a high chance of standing as a unique type in its area of use.

2. METHODOLOGY

An EOT crane will be normally operated using the direction control system provided in the remote control. When the operator experiences a problem with the speed of the crane in situations where a steady and mild movement of the crane is expected he can switch to the speed control mechanism[4]. As soon as he switches to the speed control knob the microcontroller will enable its own data channel to transmit a continuous chain of pulses. The width and frequency of these pulses can be varied for the transmission. These pulses are then transmitted using an RF unit, which is basically a Trans-receiver module. These pulses will be carried through the data channel and will be received on the other end using another RF Trans-receiver.

After the RF Trans-receiver on the receiver gets the data, it will be fed to a multi-vibrator circuit. The pulses from the micro controller will be converted to a sinusoidal signal here. The size and frequency of the sinusoidal signal depended on the size of pulses received on the receivers end. This sinusoidal signal will then be fed to the stator windings of the induction motor. As the frequency gets varied at the stator winding, the speed also varies at the motor. If there is no actual requirement of speed control, then the usual mechanism can be continued to control the crane’s direction.

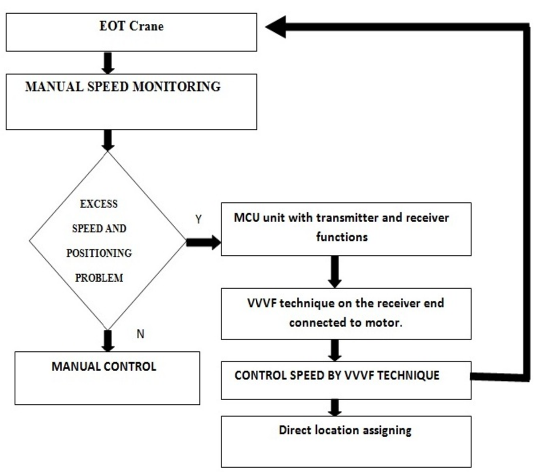

Fig. 1: Methodology

This speed control unit also comprises of an additional control provision where there will be direct control for the positioning of the crane by assigning it a location which is priority defined. This definition of prior locations can be done, once the cross travel distance is individually observed for each crane in an industry as per requirement. The braking time of the cranes cross travel is observed and noted. Then the usual drop and pickup points in the work field are noted. Then the micro controller coding is done in such a way that the crane will move to its assigned positions by stopping prior to the assigned location and allowing the braking mechanism to have enough time to reach there precisely. When the user is done with the positioning control, he will be given an option to get the cross travel hoist to its home position.

3. EXPERIMENTAL SETUP

The experimental setup consists of three prime components or divisions which are a transmitter module, a receiver module and a drive mechanism. The control is all done on a motor. The transmitter module in this project is a micro-controller[7]-ATMEGA16. As there is a micro controller on board, there will be an obvious need to control the voltage getting in. This need to control the incoming voltage will thereby bring a need to get a voltage regulator circuit in. The transmitter and receiver modules in this setup are fixed with trans-receiver modules which will be used for communication process. The RF unit used in this case is WIR-1186 module. It is a low power communication device for wireless and smart applications. It also includes an MCU for wireless network control, data handling [8], a PCB antenna and a GHz trans-receiver. The operating frequency lies between 865 MHz-869MHz. a distance range of 2km can be controlled.

The receiver end will again comprise a same set of controller and trans-receiver component [3]. The additional part of the circuit that will be joining on the receiver end will be the multi-vibrator circuit. This is a simple design made using few resistances, transistors and capacitors[5]. It is for the square wave pulses from the controller to take the shape of the sinusoidal wave. There will also be a transformer used for step-up process to control the motor. The motor used in this case is a 3-phase AC induction motor. It is a motor of a 0.5hp torque rating. The Rpm of the motor is optimum and maintained at a maximum [4]level of 1300. The i/po voltage is 240v/pc. This motor is tested in terms of speed without shaft being mounted onto a track with the help of wheels. As the normal motion is successfully controlled, the same can be achieved using a mounted mechanism.

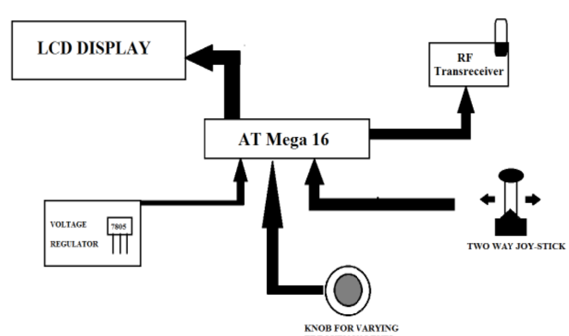

Fig. 2: Block Diagram

3.1 Design Components And Parameters

Table1: Design parameters and constraints

DEVICE	SPECIFICATION
MOTOR	3 Phase AC motor , power :- 0.5 -1hp
Control unit	Microcontroller unit-ATMEGA 16 Input ports used -1 Output ports used-2
Programming language	Embedded C
Transmission and reception	2- RF trans receiver units, Op freq -430KHz - 928KHz Op voltage- 1.9V - 3.6V Current consumption - 30mA (@ 10dBm Power)
Control pendent	Two way Joystick
Power supply	Motor Voltage- 415 v AC , frequency- 50 Hz / RC unit- 12 volt DC
Crane parameters	Capacity- Main hook- 15 ton Auxiliary – 5 ton Long travel- 200 mts Cross travel-80mts Height -65 feet.

4. OPERATOR CONSOLE MODULE

The operator is provided with a wireless remote control module in this project. This console is a microcontroller based remote control unit. A dotted PCB board was used in the fabrication. The unit comprises of an LCD display that can be seen on the top left corner of the module. There is a microcontroller ATMEGA 16 that is embedded under the LCD for compaction. The voltage regulator circuit will be allowing a 5volt output DC. A keypad is interfaced to enter the input in the case of position selection, which is connected to an input port of microcontroller. Another input that is fed to the microcontroller is through the joystick which will enable the user to control the direction of the crane. The RF trans reception device. It has a great operating range of 2Km. The buzzer will notify with a beep after a given task.

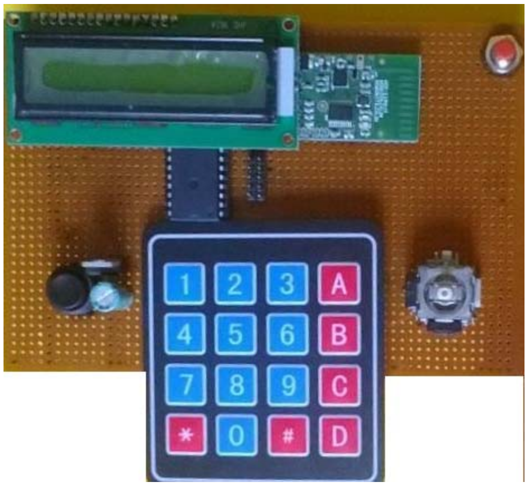

Fig. 3: Operator console

5. RESULTS AND DISCUSSIONS

This project has given us an expected set of results that satisfy the problem statement. The table in the following explanation is a representation of varying speed of a motor achieved when a varying frequency is fed to the stator winding.

Table 2: Frequency Vs Motor speed

Moving Direction	Frequency(Hz)	Motor Speed(rpm)
Right	0.0	0
Right	50.0	960
Right	65.3	1240
Right	58.3	1150
Right	54.9	1080
Left	54.9	1076
Left	58.3	1149
Left	65.3	1238
Left	50.0	959
Left	0.0	0

The graph below is a clear demonstration of how the motor speed is varying along with the varied frequency level. The red line represents the speed of the motor and the blue line is the varying frequency.

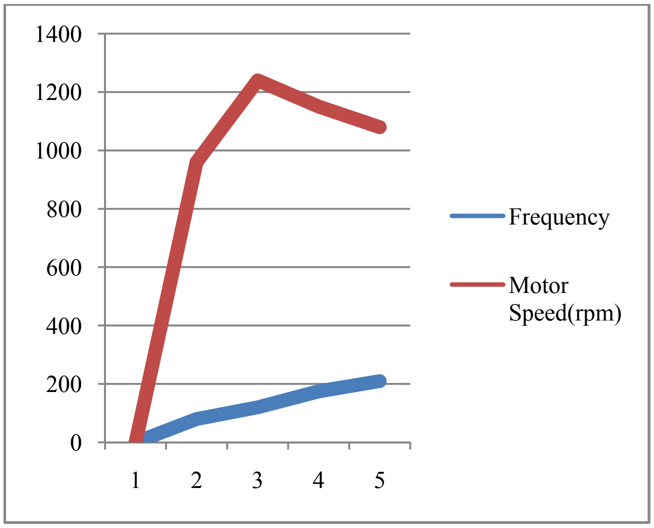

Fig. 4: Graph of Freq Vs Speed

The voltage is not varied in this operation as a variable torque is not desired. The behavior of the motor in terms of speed is significantly observed with respect to that of frequency. The following table is a representation of the series of positioning, time and distance of the predefined locations.

Table 3: Distance Vs Time

Position	Distance(mt)	Time (sec)
0	0	0
1	5	2
2	10	4.2

3	17	6.4
4	25	8.3
5	34	11.2
6	50	14.9

As shown above the cranes motor will be running for that particularly assigned time and will be turned off. This will allow the hoists momentum to push it and slow down to ‘0’ at the location required.

6. CONCLUSION

The project has successfully achieved the system of speed control for the EOT crane operation. This was done at an experimental level to have a compatibility to upgrade the setup whenever required. The micro controller unit is also programmed well for the desired task. The variable frequency method is successfully implemented. The predefined positioning of the crane hoist is also well achieved in operation. As the results are recorded with respect to a motor with a free rotating shaft, they might slightly differ from that of a mounted shaft. Anyways, as the project is not dealing with the load and torque characteristics the mounting of shaft will not play a significant role. With a better level of hardware and inter face, this application can be taken to an industrial level.

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