Wireless Control Modelling for Overhead Crane

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Abstract. Radio frequency (RF) remote controllers are widely used in manufacturing, construction, transportation, and many other industrial applications. Cranes, drills, and miners, among others, are commonly equipped with RF remotes. Installation wired communication takes a long time to set up the connection as compared to the wireless connection. The installation becomes very lengthy and complex if we want to get connected with each router. For the same reason, for a system expansion to add more device(s), the re-routing process to connect this new device(s) to the network can be avoided. Instead, with the wireless connection, we don’t have to perform all the setup again. The network can be accessed with the authorized passcode. Radio-controlled devices are ubiquitous in all sorts of industries. In fact, many cranes are now being equipped with radio-controlled technology, which is revolutionizing the way crews move materials around a warehouse or job site. In the steel manufacturing industries, the wireless crane control has proven to assure more advantage compared to the disadvantage. Through the surveillance and monitoring of wireless remote control for crane that done at AJSB, Prai, Malaysia.

1. Introduction
The wireless radio communication provides more reliability even in a harsh environment, which is specifically used in critical and industrial applications. Wireless communication offers cost-effective, easy installation and mobility, few manpower needed for crane operation as compared to wired communication (3-4). When compared with a wired connection, a wireless connection requires minimum maintenance. For instance, if an underground cable damages, we need to repair or replace the cable, which will cost high. In comparison, wireless communication does not require such kind of maintenance.

In a long-distance wireless communication, Access Points (AP) can be installed to amplify the signals. So, over a long distance, the signal does not attenuate significantly, nor distortion created in that signal. Hence, this feature of wireless communication also offers better safety conduct operation of the crane compared to wired control. Overhead cranes are successfully applied in diverse fields for the manufacturing steel industry as one of the important logistic equipment’s (2). This research study focuses on two main objectives; first, to investigate the performance of wireless signal processing of crane control system in the steel manufacturing industry. Second, to design a control improvement
starter that is reliable with current technology for crane control function in the steel manufacturing industry.

2. Methodology
There are 2 phases in order to complete this research study:

**Phase 1:** Investigation the effectiveness of wireless signal processing for crane control system as shown in Figure 1. The design consists of receiver and transmitter. The receiver has a microcontroller function as data reading and organizing industrial network such as Ethernet communication. The transmitter is a part of control box or individual device mounting on a rack, a wall, a plate, or portable device which is non-mounting (1).

From this studied the performance of wireless cable signal processing could be determined by

- a) Designed the new device of wireless signal processing in range of medium and high frequency.
- b) Designed the receiver and transmitter sensor for fastest communication sensor and reliable with high frequency transmission signal.
- c) Analyze the new signal processing in term of efficiency, signal strength, locality, and distance.

**Phase 2:** Design new induction motor circuit as motor starter for crane control system for improvement motor start running as shown in Figure 2.

- a) Defined type of control system which is hoisting, travelling, and crossing.
- b) Designed new starter motor based on slip ring AC motor.
- c) Build circuit diagram included power and control circuit diagram to synchronized with wireless device.
- d) Tested, run, and analyze.

![Figure 1. Crane Wireless Control](image1)

![Figure 2. Crane Motor Starter](image2)

2.1. **Crane Wireless Control Design**
Made up of three mains system which are Control Panel, Receiver and Transmitter.

2.1.1. **Control Panel.** A control panel with schematic drawing of crane movement which is Hoisting, Crossing and Travelling movement that are designed in this project such as in Figure 3. Hoisting, Relay 1 (R1) and Relay 2 (R2) is function for UP 1S and UP 2S for first step (low speed) and second step (high speed) for hoisting movement upward accordingly. Relay 3 (R3) and Relay 4 (R4) is function for Down
1S and Down 2S for first step (low speed) and second step (high speed) for hoisting movement downward accordingly. Relay 5 (R5) and Relay 6 (R6) is function for Joystick and Remote Selection. Relay 7 (R7) is function as an interlock for hoisting movement upward and downward. Figure 3 also shows that hoisting resistor step. Relay 7 (R7) and Relay 2 (R2) contact were used for resistor step functioning. Furthermore, the Figure 3 also shows that contact for Emergency Stop (E/S) release, Selector ON and Start Button for hoisting crane operation. While for Crossing (Trolley), Relay 8 (R8) is function for East 1S for first step (low speed) for crane movement to east direction. Relay 9 (R9) is function for West 1S for first step (low speed) for crane movement to west direction. Relay 10 (R10) is function for East/West 1S for first step (high speed) for crane movement to east/west direction. Lastly for Travelling, Relay 11 (R11) and Relay 12 (R12) is function for South 1S and North 1S for crane movement to south and north direction. Relay 13 is function for South/North 1S movement high speed first step.

![Figure 3. Schematic Drawing for Hoisting and Trolley Circuit Control](image)

2.1.2. Receiver and Transmitter. A receiver and transmitter that are used in this project such as shown in Figure 4. The circuit control in Figure 4 shows that function of hoisting crane movement that was explained in Figure 3 and overall crane movement.

![Figure 4. Schematic Drawing for Receiver and Transmitter Circuit Control](image)

2.2. Crane Motor Starter Design
Made up of three mains system which are Control Panel, AC Drive and Motor.
2.2.1. **AC Drive and Motor.** An AC Drive or Variable Frequency Drive (VFD) or Inverter and the motor type that are used in this project is Induction Motor (Squirrel Cages) as shown in Figure 5. The external wiring for power supply control such as breaker (NFB), contactor (MC) linked to VFD via terminal R/L1, S/L2 and T/L3. Then VFD control to covert AC supply to DC supply for switching control or command such as motor running in forward and reverse then back to AC supply for motor start running and stop running. Furthermore, the external circuit also contain thermal overload relay for high temperature and high current protection before power supply to VFD. Lastly, external circuit also designed with brake unit by VFD 24VDC supply + (P) and –(N) for motor brake emergency stop function.

![Variable Frequency Drive (VFD) and Induction Motor (Squirrel Cage)](image)

**Figure 5.** Variable Frequency Drive (VFD) and Induction Motor (Squirrel Cage)

2.2.2 **AC Drive Parameter.** Figure 6 below shows the list of parameters setting for VFD. It contains of important motor data need to be set up such as Motor rated voltage (V), Rated motor current (A), Rated motor power (kW/hp), Rated motor frequency (Hz) and Motor rated speed (rpm).

![AC Drive Parameter Setting (Motor Data)](image)

**Figure 6.** AC Drive Parameter Setting (Motor Data)
3. Results and Discussion

3.1 Crane Wireless Control Design

Table 1, Table 2 and Table 3 are the phase 1 analysis of the new signal processing in term of efficiency, signal strength, locality, and distance for crane wireless control design.

3.1.1 Table 1 shows the Joystick / Termination / ON OFF Switch / Buzzer / Siren / Bell analysis.

| Analysis point | Actual Condition |
|----------------|------------------|
| Hoisting       | Good             |
| Trolley        | Good             |
| Travelling     | Good             |

3.1.2 Table 2 shows the Panel of Termination / Contact piece / Humming contactors / Cleanliness / Sparking analysis.

| Check / Analysis point | Actual Condition |
|------------------------|------------------|
| Hoisting               | Good             |
| Trolley                | Good             |
| Travelling             | Good             |
| Distribution           | Good             |
| Incoming               | Good             |

3.1.2 Table 3 shows the Resistor of Sparking and Termination analysis.

| Check / Analysis point | Actual Condition |
|------------------------|------------------|
| Hoisting               | Good             |
| Trolley                | Good             |
| Travelling             | Good             |

3.2 Crane Motor Starter Design

Table 4 until Table 8 are the phase 2 analysis of the new signal processing in term of efficiency, signal strength, locality, and distance crane motor starter design.

3.2.1 Table 4 shows that the rated current (ampere) for three motors crane

| Check / Analysis point | Actual Condition |
|------------------------|------------------|
| Hoisting               | 27.5A            |
| Trolley                | 6.9A             |
| Travelling             | 28.4A            |

3.2.2 Table 5 show that the free load test current (ampere) for three motors crane.

| Check / Analysis point | Actual Condition |
|------------------------|------------------|
| Hoisting               | Starting Current |
| UP                     | 23.6             |
| DOWN                   | 23.5             |
| Hoisting               | Running Current  |
| UP                     | 10.6             |
| DOWN                   | 10.1             |
Table 6. Free load test current (ampere) for Trolley Motor

| Trolley | Starting Current | Running Current |
|---------|------------------|-----------------|
| UP      | 5.6              | 3.2             |
| DOWN    | 5.2              | 3.4             |

Table 7. Free load test current (ampere) for Travelling Motor 1

| Travelling 1 | Starting Current | Running Current |
|--------------|------------------|-----------------|
| UP           | 21.8             | 10.2            |
| DOWN         | 22.2             | 10.2            |

Table 8. Free load test current (ampere) for Travelling Motor 2

| Traveling 2  | Starting Current | Running Current |
|--------------|------------------|-----------------|
| UP           | 22.0             | 11.0            |
| DOWN         | 21.9             | 10.7            |

4 Conclusion

Wireless control is the best crane control due to the circuit control design for crane movement Hoisting, Crossing and Travelling to link with Receiver and Transmitter is effectively and efficiently matched for crane remote control. While motor starter design via Variable Frequency Drive (VFD) or Inverter can improve on motor start running in term of safety, energy saving and mechanical part such as coupling, gear box and wheel.

Most of crane accidents are usually caused by the lack of crane safety monitoring systems and lack of monitored crane safety parameters. The improvement is novel research for control system in steel industry due to cost saving for maintenance and upgrading. Safety concern for human or operator once operate crane, less manpower needed for crane operation, reduce time operation then would increase up productivity. In future, Industrial Internet of Things (IoT) can be implemented to provide a strong enabling toolset to the reliability efforts of steel manufacturing or heavy industry.

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