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Wireless Control of Electrical Overhead Trolley/ Crane using STM32 and nRF24L01

Rajkumar. G. Jha, Aditya Manjrekar
Hrishikesh Pawar, Akanksha Dhivar
Prof. Jyoti Gurav
Department of Electronics and Telecommunication Engineering
Atharva College Of Engineering
Mumbai, India

Abstract: It is explained that the operator communicates with gantry cranes using radio frequency technology to collect pertinent information and manage their activity. Two components make up the frequency communication system: one is positioned on the crane to gather working and environmental data; the other is operated by the operator to maintain the crane operational and observe the crane's operating parameters in real-time. To avoid interference from similar equipment and the outside world, the two components might be set to the same address. Frequency communication has a 100-meter maximum transmission range. Instead of sitting in the 10m-high cab, the operator can operate the machinery from the ground. The site's successful completion of experiments in the Mumbai city dock demonstrates the method's dependability and safety.

Keywords: Overhead Travelling Crane Automation, RF Technology, Distance transmission, Wireless Control, Microcontroller, Transceiver.

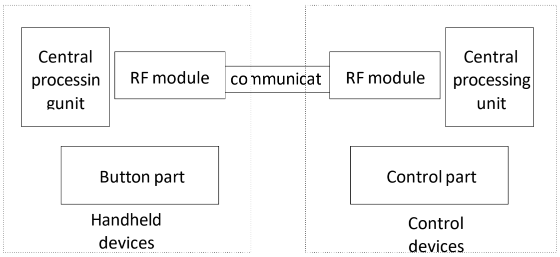
1. INTRODUCTION

Radiofrequency technology has gotten more and more attention since the turn of the century. [1]. Cranes are specialised machinery, and their safety is tied to both the country's economy and the livelihood of its citizens. The effects of an accident would be immeasurable. The crane sector is a part of the machinery sector, but most of these sectors are currently either non-automated or semi-automated. One major challenge the old machinery industry has is how to transform it into a new sector of completely automated control. Using video technology to the conventional machinery business is very important.

In order to gather data about the crane's working environment, including wind speed and direction, as well as information about the crane itself, this article suggests using wireless technology to interact with the crane. Also, you may regulate the crane trolley's, main crane's, electric hoist's, and left and right movement [2].

2. HARDWARE PARTS

According to Figure 1, the hardware has a modular design and is split into two sections, one of which is a handheld device [3] that a technician uses on-site. The control component, which is positioned on the crane to oversee its operations and gather data on its operating conditions and environmental parameters, is the other component. The two components communicate via radio frequency, as seen in Figure 1. The central processor unit and the radio frequency portion are the



same two components.

1.1. HANDHELD DEVICE DESIGN

1.1.1. Power supply section

As seen in Figure 2, the circuit is powered by a lithium battery, which generates a 12V DC voltage that is reduced to 5V by a 7805-regulator tube. The lithium Battery's 8 Ah

Figure 1: The total schematic diagram of the hardware

capacity is sufficient to handle the demands of the building process.

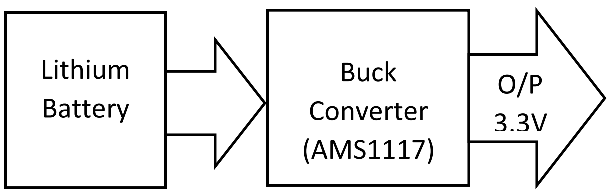


Figure 2: Schematic of power in a handheld device

1.1.2. RF Part

As depicted in Figure 3, the module uses the authentic, imported Norwegian nRF24LO1P chip, and all of the peripheral resistance-capacitance sensing components, particularly the crystals, are imported to ensure their industrial features [4] [5]. The body of the 0402 package, which contains the resistors, capacitors, and inductors, is incredibly compact. The performance of the module is good because to the use of Murata sensing container parts and an imported crystal with an accuracy of 10 ppm. The module's 50-100 m open transmission distance can accommodate operating in open areas. The module features an SPI interface, and the external microcontroller interacts with the module through SPI to complete wireless data transmission and reception as well as register setting and reading. When the microcontroller communicates, a 1K resistor is linked in series with the module's power supply voltage, which can range up to 3.6V. The single-chip microcomputer's antenna cannot be placed close to any metal items that have a substantial impact on it, and the shell cannot be constructed of metal because that would shorten the distance.

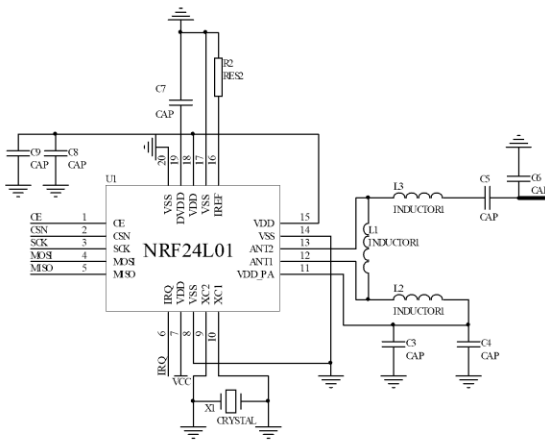
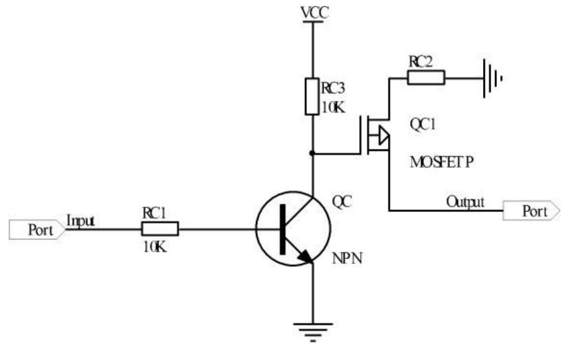


Figure 3: Schematic of RF circuit

1.1.3. Central Processing Unit

The on-chip computer that uses the STM32 series is based on the **ARM Cortex-M3 core** specially designed for embedded applications that require high performance, low cost, and low power consumption. The basic clock frequency is 36MHz, and the performance of 16-bit products is greatly improved at the price of 16-bit products. It is the best choice for users of 32-bit products. Both series have built-in flash memory of 32K to 128K, the difference is the combination of

Figure 4: STM32 32-Bit Arm® Cortex®-M MCUs



the maximum capacity of SRAM and the peripheral interface. When the clock frequency is 72MHz, the code is executed from the flash memory, and the STM32 consumes 36mA, which is equivalent to 0.5mA/MHz.
The microcontroller is a kind of integrated circuit chip, which

1.2. Control Equipment

1.2.1. Power Supply Section

For the purpose of powering the microcontroller and its auxiliary circuitry, the portable portion of the power supply converts a 380V industrial power supply to a 5V power source. China BoPai modules are used in the power supply. The module includes full output overvoltage and overload protection features, CLASS B-compliant conduction, powerful anti-surge protection, and group pulse interference immunity. Its efficiency is higher than 5%.

1.2.2. Control Part

Elements of information gathering include: lifting weight limiters, lifting height limiters, descending depth limiters, running stroke limiters, deflection limiters, interlock protection safety devices (door limits, operation interlock between institutions), anti-wind and anti-skid devices, anemometer devices, rotation limiters, anti-collision devices of the same or different track running mechanisms.
The following parameters are being monitored: lifting height, descent depth, running stroke, cart running deflection, wind speed, safety distance of the same or different track running mechanism, operating instructions, working time, accumulated working time, each working cycle, lifting mechanism brake status, anti-wind and anti-skid status, interlocking protection (door limit, interlocking operation between institutions), and power supply cable reel status.
As seen in Figure 5, the microcontroller's I/O pins are linked

Figure 5: Diagram of controlling external sensor circuit

to the input on the left, and the sensor port that will be controlled is connected to the output on the right. Control the sensor to operate at low levels of microcontroller output. The sensor, however, is inoperative.

2. SOFTWARE PART

The software is split into two sections: the control section and the portable device section. When the two components leave the factory, they must be setup with the same address, and if they are, they can communicate with one another. It's possible for there to be more than one crane on the same building site, so setting up different addresses will help you avoid interference.
Using the SPI interface, the one-chip computer talks to the radio frequency module. The analogue SPI interface is used by the single-chip microcomputer, which helps to conserve its IO pins.

2.1. Handheld equipment

Use handheld devices to radio frequency-communicate with the crane in order to start, work, and stop the crane. According to Figure 5, pressing the matching handheld device work button causes it to transmit a control command. When the control device responds with information, the command is stopped and the handshake is successful. The control command must be sent again if the feedback signal is not received, which indicates that the control equipment is malfunctioning. The control command will halt and the error signal light will be on if there isn't a feedback signal at this point.

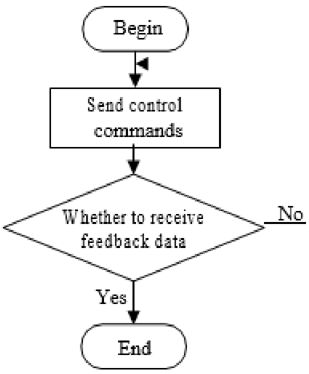


Figure 6: Program flow handheld equipment

Hexadecimal 8-bit data delivered includes the following information: AA, data length, sensor code, address, control sensor code, control sensor action, and CRC check high and low bytes.

2.2. Control Part

After receiving the control signal, like in Figure 7, determine whether the address corresponds or not. The device won't react if the address is incorrect. After it determines that the address matches this machine, it will reply to the message sent by the handheld device and then command the operation of the crane.

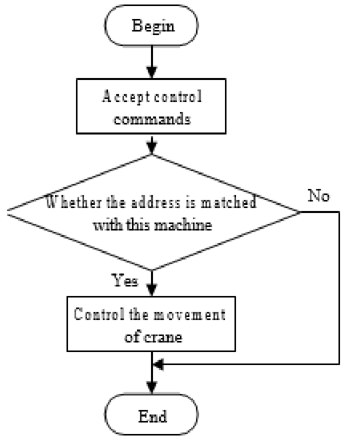


Figure 7: Program flow of controlling device

Hexadecimal data delivered includes the following 6 bytes: address, 55, data length, sensor code, 1, CRC check high byte, and CRC checks low byte.

3. EXPERIMENTAL RESULTS

The laboratory has finished the shop inspection test. It is applied to L&T crane equipment once it has been completed in the lab [7]. Table 1 presents the measurement information.

***Table 1**: Crane monitoring parameters*

Monitoring type	Numerical value
Lifting height	5m
State of Lifting mechanism brake	Stop
Travel speed of a cart	1m/s
Cumulative working time	20 hours

4. CONCLUSIONS

The outcomes of laboratory and field tests demonstrate that the radio frequency system provides the following benefits:
1.) Large transmission distance. Cranes work primarily outdoors or in open spaces indoors, and the transmission distance can reach 100 metres.
2.) The crane can be operated by the employees for work on the ground. Formerly, the crane's driver's cab was located at a height of around 10m, making it difficult for the personnel to work. The crew may work freely thanks to this radio frequency system.
3.) Manufacturing of crane equipment is a part of the machinery sector. Manual labour is used for both production and manipulation, and many cranes' operating parameters cannot be tracked or compiled. This radio frequency system

now makes it possible to fully automate the crane. The staff can easily spot anomalies in the construction process by keeping an eye on the crane's working conditions on the job site.

A system based on radio frequency technology reduces the need for labour and material resources while raising the level of safety during construction.

5. COMPARATIVE

The results of the performance experiment on the wireless communication system for the tower crane fleet based on the ZigBee module and the STM32 with the NRF24L01 module are as follows.

Following practical investigation and theoretical analysis, the dependability and correctness of wireless data communication systems were confirmed:

1.) An error rate of less than 10^{-3} and a 95% confidence level. The real network transmission delay is 16 ms, less than the required value of 25 ms, which can ensure no package loss. The real error rate is 0, which effectively guarantees the accuracy of the data transmission. (2) Safe and stable network transmission delay is 0 ms, effectively ensuring no data transmission errors.

6. REFERENCES

1. https://www.researchgate.net/publication/261089179_The_crane_control_systems_A_survey
2. D. Liu, B. Yu, M. Liao, et. al., Self-Powered and Broadband Lead-Free Inorganic Perovskite Photodetector with High Stability, ACS Applied Materials & Interfaces, 12.27(2020) 30530- 30537.
3. https://www.researchgate.net/publication/258162496_Dynamics_and_Control_of_Cranes_A_Review
4. https://www.sciencedirect.com/science/article/pii/S1110016821000521
5. Sitompul, T.A.; Wallmyr, M. Using Augmented Reality to Improve Productivity and Safety for Heavy Machinery Operators: State of the Art. In Proceedings of the 17th International Conference on Virtual-Reality Continuum and Its Applications in Industry (VRCAI '19), Brisbane, Australia, 14–16 November 2019; ACM: New York, NY, USA, 2019; pp. 8:1–8:9. [CrossRef]
   I. Mahariq, M. Kuzuog˘lu, I.H. Tarman, On the attenuation of the perfectly matched layer in electromagnetic scattering problems with the spectral element method, ACES J. 29 (9) (2014) 701–710. Corpus ID: 64629771.
6. Huawei, Smart Port 2019, 5G Smart Port White Paper,2020,https://www.file.huawei.com//media/corporate/pdf/xlab/2019/5gsmartportwhitepaperen.pdf?la=en.
7. Y.-S. Kim, K.-S. Hong, S.-K. Sul, Anti-sway control of container cranes: inclinometer, observer, and state feedback, Int. J. Control, Automation, Syst. 2 (4) (2004) 435–449.
8. Humusoft, Data acquisition card, 2018. https://www.humusoft. cz/ datacq/mf634/.
9. K. Ogata, System Dynamics, Fourth Edition., Pearson Education, 2013.
10. S. Bayari, 2020. The dynamic equilibrium method education notes, http://yunus.hacettepe.edu.tr/~bayari/FZO%20301%20Titresim%20ve%20Dalgalar/BOLUM-3-Y.pdf.
11. Tobb Etu¨, 2020. The dynamic equilibrium method education notes, http://fizikservis.etu.edu.tr/ders16.pdf.
12. O. Sawodny, J. Neupert, E. Arnold, Actual trends in crane automation – directions for the future, FME Trans. 37 (2009) 167–174.
13. N.A. Armstrong, P.R. Moore, R.H. Weston, Generic Crane and Hoist Automation with the Application of Advanced Control Architectures, Automation and Robotics in Construction X, Elsevier Science Publishers B.V., 1993. http://dx.doi.org/10.22260/ISARC1993/0013
    S.-T. Wu, Y.-R. Chen, S.-S. Wang, Two-degree-of-freedom rotational-pendulum vibration absorbers, J. Sound Vib. 330 (2011) 1052–1064, https://doi.org/10.1016/j.jsv.2010.09.028.
14. Wang Jinchuan, Qin Zhen, Han Yu. Development status and application of radio frequency technology [J]. Application of Electronic Technology, 2007, 33(7): 5-11.
15. Tan Xiaodong, Li Zhong, Li Baoliang. Railway crane electrical control system based on PLC control technology [J]. Journal of Dalian Jiaotong University, 2009, 30(5): 15-18.
16. Cao Lifeng, Hu Jinping, Cao Guangzhi. Design of input signal filter for crane controlhandle [J]. Manufacturing Information, 2013, (6):111-113.
17. Zhang Yemao, Zhang Jiangong, ZhangGuangzhou, etc. Design of wireless communication DC electric field measurement system based on nRF905 module [J]. High Voltage Technology, 2012, 38(11): 2869-2874.
18. Mo Xiaojin, Zhou Yan. Temperature and humidity remote monitoring system based on radio frequency technology and wireless network [J]. Journal of Sensor Technology, 2011,24(10): 1501-1505.
19. Zhou Weifang, Rong Yue. Design of long-distance transmission controller based on single-chip microcomputer [J]. China New Technology and New

Products, 2012, (8): 22-23.
20. Zhou Yuanhui. Research and implementation of the control system of the straw bale grab crane [D]. Xi'an: Xi'an University of Science andTechnology, 2008.
21. H. Li, P. Xu, et. al., Low-voltage and fast-response SnO2 nanotubes/perovskite heterostructure photodetector, Nanotechnology,32(2021)375202.
22. Wang, Y., Wang, W., Yang, X., et. al., ITGA8 positive cells in the conventional outflow tissue exhibit Schlemm's canal endothelial cell properties, Life Sciences, 278(2021)119564.
23. P. Xu, J. Cao, et. al., Quantum chemical study on the adsorption of megazol drug on the pristine BC3 nanosheet, Supramolecular Chemistry, 33(2021)63-69.
24. J. He, X. Liu,et al. High Annealing Stabilityof InAlZnO Nanofiber Field-Effect Transistors with Improved Morphology by Al Doping. Journal of Physical Chemistry Letters, 12.4(2021)1339-1345.
25. H. Zu, Y. Chang, H. Li, et. al., Modulating the Transport Properties of Metal Oxide Nanofibers Transistors by Controlling the Grain Size. IEEE Electron Device Letters. 42.6(2021)855-858.