

## Design and Analysis of Motor Control System for Wireless Automation

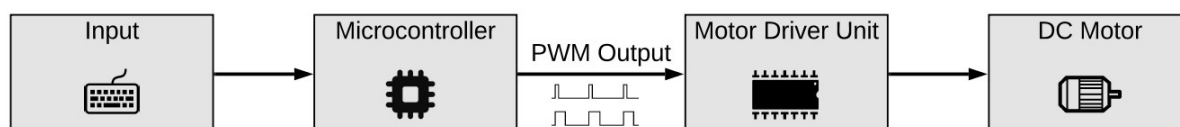
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**Abstract:** Space availability is one of the major parameter to be considered for structuring a control system. The control system installation occupies space for motors, control circuits, wiring connection and driver units. The motive of this work is to minimize the space requirement for a motor control system by making a wireless communication between the motor driver unit and control unit. The design saves the space requirement for control circuit wiring and control circuit unit. The design is helpful in minimizing the overall space requirement of the motor control system. As the control unit is made with wireless communication, the control unit can be moved anywhere near to the system. This improves the accessibility of the system at fault rectification time and precise operation time. The result indicates the reliability and efficiency of the proposed system with various parametric evaluations.

**Keywords:** Wireless motor communication, flexible control unit, wireless control drive, motion control wireless data transfer.

### Introduction

Motors are widely used in industrial applications, automation process and robotic movements. Most of the time the motors are fixed with a control unit for giving command on desired operations. The traditional electrical control circuit consists for contactors and relays for operations but the recent control circuits are replaced with electronic integrated circuits for saving the cost, space and power requirement of the circuit. In both traditional and electronic control circuits the motor is connected through a wired structure for giving communication signal. Figure 1 indicates the basic blocks involved in an electronic control circuit. The recent development in wireless communication makes possibility on sending signals between the control circuit and motors without wire connections. This improves the flexibility of the motor connected system. The wireless communication between the motors and control circuit eliminates lot for circuit wiring confusion during reinstallation and fault rectification process. The wireless growth improves the freedom on placing the motor in robotic and automation applications.



**Figure 1. Microcontroller based motor control unit.**

There are certain limitations in wireless communication control unit and they are mostly because of time delay in transmitting the signal. The signal transmission delay can be calculated by the equation 1. Apart from time delay the bandwidth restriction plays an important role while installing the motors for little longer distances. Data loss and disconnection in wireless communication also plays a major role in the efficiency of the wireless communication. Wireless communications are effortlessly attackable in general. A perfect design of wireless system can overcome

these drawbacks and achieve efficient transmission. The recent secure wireless communication techniques introduced for several applications are discussed in the following section.

$$Time_{delay} = Time_{process} + Time_{network} \quad (1)$$

### Related work

The wireless communication is applied to many fields for transmitting data and signals from one place to another place without physical connection medium. The wireless communication avoids cable fault delay and minimizes the installation and maintenance cost of the communication medium. The wireless communications are successfully applied to several schemes in medical practice, agriculture, engineering, sports and entertainment. A wireless servo motor drive system [1] was proposed to eliminate the presence of power controller in motor drive system. The proposed method has the ability to control the bidirectional movement of the servo motor. The wireless communication is made with a LCL network for power compensation to the receiver side coils. In the receiver side there are two coils were fixed to control the bidirectional motion of the servo motor. The wireless communication distance achieved 130mm displacement between the coils. An industrial robot was designed for sensing and manufacturing process [2] with RF signal transmission. The process consists of two microcontrollers, one for encoding the input signal and transmission another one for receiving signal, decoding and motor driver unit. The response time of the motors from the input value is measured in this work and it attains 4 to 5 seconds delay in operation with error percentage not more than 3.

A myoelectric signal based robotic arm control system [3] was developed to control the motor movements in a robotic arm structure. For this 10-50MHz of wideband impulse radio system was hired for transmission process. The developed model achieved higher coefficient correlation between the transmitter and receiver signals. A 6 axis mechanical arm structure was made to control by computer vision architecture [4] for classifying the objects for placing in the right location. The architecture was trained with a 3D printer with tracking algorithm of the existing models. A wireless sensor based intelligent car [5] was established with two microcontrollers. The STC12C5A60S2 and STC89C52RC are the microcontrollers employed in the model for master and peripheral process respectively. The car is equipped with a Wi-Fi digital camera for verifying the environment surroundings along with Bluetooth based GPS positioning, IR sensor, driver unit and LCD display for verifying the status of the connected system. The driver unit is fixed with the steering motor for left and right control. The developed model is designed for unmanned vehicle movement.

A surgical telerobotic delay reduction technique [6] was framed to minimize the surgical errors due to delay and latency of transmission signals. The technique is designed with self-automation and self-correction algorithm at the receiver end for manipulating the errors intelligently. The safety is improved by taking a feedback from the control unit to the base station for continuous monitoring. An IoT based wireless monitoring and control system for induction motor [7] was prepared for remote monitoring and remote controlling the motor. For monitoring purpose several sensors were used to read and for control the transferred information is collected by the microcontroller through an Ethernet structure. A microcontroller in the motor side is connected with sensor modules and Ethernet module for information sharing and a raspberry pi controller is fixed in the control unit side for acting as an I/O manager to display the status of the motor along with input information carrier. Cayenne IoT database was employed in this work for information transfer process. Information maintenance on cloud based architecture with computational intelligence [8] was presented here to secure the data information transferred through cloud structure. The information moved to the cloud databases are encrypted to a specific format with computational intelligence algorithm for secure purpose and the data are again decrypted when it is accessed by an authenticate user request. The data in the cloud database is secured in this rule from hacking tools and manipulation tools.

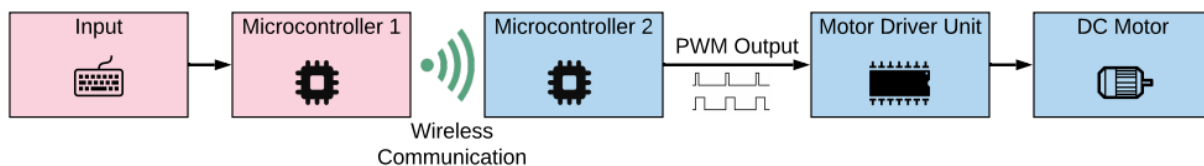
A wearable wireless device for electromyography [9] was designed to collect the information gathered from the connected electrodes wirelessly for further analysis process. The wireless transmission is achieved through two numbers of CC1110 transceiver connected on transmission and reception side. The signals gathered from the electrodes are processed and converted in to digital form for transmission purpose. Similarly, the receiver collects the digital data and forwards it to a computer analyzer through USB interface. The IoT application benefits are discussed

[10] in terms of energy efficiency in utilization and intelligent processing of collected data. An inductively connected power transfer system [11] was established to power the artificial limbs connected with prosthetic hands. The wireless power transmission system was developed to overcome the power drain disadvantage in the prosthetic hand machine. The class E power amplifier was activated here for transmission process and a commercial receiver circuit was kept near along with contactless coils. A Wi-Fi technology based IoT transmission of sensor data from agriculture field [12] was deployed with a netduino 3 controller. Here the controller is directly connected with group of sensors necessary to monitor the field for data transmission. As the netduino controller has inbuilt Wi-Fi transmitter, it transmits the data to the receiver end for alerting.

A wireless control system for solar power generation module [13] was proposed to monitor the status of power generation from remote places. The solar panel is fixed to a DC motor through H-bridge circuit for changing the driving options of the motor. The system is connected with a zigbee transceiver for communication purpose and an arduino microcontroller for transmitter side control along with an atmega 16 for controller side operations. A switched reluctance motor was powered wirelessly [14] with transmission supply efficiency of 72.8% in 150mm distance. The design is equipped with a Bluetooth transceiver on motor and control side for finding the position feedback of the motor. With respect to the received information the transmission energy frequency is altered to reach the respective coils fixed in the receiving side. A precise agriculture system [15] was developed using wireless sensor networks for monitoring and control purpose. The system is employed with an arduino microcontroller and an Intel Galileo Gen2 board for operations. The arduino board is connected with sensors for data acquisition and Wi-Fi transmitter for transmitting the data to manual analysis. The manual decision is digitally transmitted to the Intel board through Wi-Fi transmission again for comparing the manual decision with the cloud based signals. The information from the clouds are about the present atmosphere and local market condition. With all those data the agriculture field is maintained by the Intel board on its artificial intelligence.

### Proposed Method

From the literature review, it is clearly observed that the wireless control unit requires two number of microcontrollers and a secure wireless transmission. Figure 2. Indicates the proposed architecture for controlling the motor unit. The proposed design is also equipped with two microcontrollers, one for transmission side operations and another one for receiver side operations. The transmission side microcontroller is connected with an alphanumeric board for giving desired input to the motor. As the proposed model is a one way communication process, there is no display board is fixed for detecting the status of the motor. A digital display or LED lights can be fixed for finding the status of input if needed. The proposed model is designed for applications with motor and control circuits are need to be moved like hoist kind of applications.



**Figure 2. Proposed wireless communication control system.**

The hoist motors are usually fixed over certain height from the operating person and the length of supply wire and control wires makes certain difficulties in some particular operations. In order to avoid such issues the proposed system can be used. The control unit consists of microcontroller with a wireless transmitter for sending the control signal to the microcontroller placed near the motor. The receiver side microcontroller receives the control signal and changes the PWM generation according to the signal received. The change in PWM is received by the motor driver unit for giving the desired supply output to the motor. In this method, the motor speed and direction can be adjusted. The movement of the motors can be visually verified in this system. The proposed model is not suitable

for non-visually verified applications. The transmission can be enabled with any kind of wireless communications. The proposed model is verified with several wireless medium for identifying the suitability of a wireless method for the hoist kind of applications.

## Experimental Results

The proposed method is verified with Bluetooth, and Wi-Fi communication for finding its range reliability. The transmitter and receiver module on the general structure mentioned in figure 2 is change according to the communication module involved in the work. HC-05 Bluetooth transceiver module was fixed for verifying the Bluetooth suitability in the proposed model. Certain specified commands were given to the receiver side microcontroller for communication verification. The response of the motor side is given in table 1. The communication is verified with physical interruption made in between the transmitter and receiver by keeping a standard 6 feet to 6 feet tall sheet as obstacle.

**Table 1. Response of the receiver module with Bluetooth communication.**

Distance	Command	Output Response without obstacle	Output Response with obstacles
5 Feet	Motor ON	Working	Working
	Motor OFF		
	Motor Forward		
	Motor Reverse		
10 Feet	Motor ON	Working	Working
	Motor OFF		Working
	Motor Forward		Not working
	Motor Reverse		Working
15 Feet	Motor ON	Working	Working
	Motor OFF		Not working
	Motor Forward		Not working
	Motor Reverse		Working
20 Feet	Motor ON	Working	Working
	Motor OFF		Not working
	Motor Forward		Not working
	Motor Reverse		Not working
25 Feet	Motor ON	Working	Not working
	Motor OFF	Working	
	Motor Forward	Not working	
	Motor Reverse	Not working	
30 Feet	Motor ON	Not working	Not working
	Motor OFF		
	Motor Forward		
	Motor Reverse		

Similarly the proposed model is verified with ESP8266 Wi-Fi transceiver for verifying the output control communication between the motor and transmitter unit. The results observed on testing is given as table 2.

**Table 2. Response of the receiver module with Wi-Fi communication.**

Distance	Command	Output Response without obstacle	Output Response with obstacles
10 Feet	Motor ON	Working	Working
	Motor OFF		
	Motor Forward		
	Motor Reverse		
25 Feet	Motor ON	Working	Working
	Motor OFF		
	Motor Forward		
	Motor Reverse		
45 Feet	Motor ON	Working	Working
	Motor OFF		
	Motor Forward		
	Motor Reverse		
60 Feet	Motor ON	Working	Working
	Motor OFF		Working
	Motor Forward		Working
	Motor Reverse		Not working
75 Feet	Motor ON	Working	Working
	Motor OFF		Not working
	Motor Forward		Working
	Motor Reverse		Not working
100 Feet	Motor ON	Working	Not working
	Motor OFF		Working
	Motor Forward		Not working
	Motor Reverse		Not working
110 Feet	Motor ON	Not working	Not working
	Motor OFF		
	Motor Forward		
	Motor Reverse		

From the experiments conducted with Bluetooth and Wi-Fi modules, it is clearly observed that the communication transceivers can be reliable to its 50% of maximum range mentioned with obstacles. The proposed technique is reliable at where the system gets physical or communication acknowledgment from the receiver module or the system can be implemented with 50% percentage of the range mentioned by the datasheet of the modules.

## Conclusion

The proposed concept of wireless communication control unit is possible with any communication device. The limitation observed by the verification of signal indicates the devices are reliable up to 80% of the mentioned range without obstacles and 50% reliable when there is an obstacle between the transmitter and receiver unit. The experiment conducted explores the communication devices to be verified for multiple number of times before enabling to the real time operations. A confirmation signal or sound from the transmitter side during the operation can improve the model reliability.

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