DESIGN AND DEVELOPMENT OF A PROTOTYPE AUTOMATIC SLIDING HOME GATE WITH A WIRELESS CONTROL SYSTEM

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ABSTRACT
The purpose of this work is to design and construct a prototype automatic sliding home gate with a wireless control system. The operation of manual home gate is not only cumbersome but tiring. Therefore, the development of automatic home gate with wireless controlled system proof important. In this research, a prototype of automatic sliding home gate with wireless control system is implemented. The research was fully developed using radio frequency signal transmission and reception system, microcontroller and DC motor. The final prototype design shows that signal is generated by a transmitting handheld remote control at ultra-high frequency. The signal is decoded by the reception module to give out a digital output. The digital output is coupled to a microcontroller which makes a decision to either open or close the gate by driving a direct current stepper motor logically based on the previous conditions.

Keywords*: Sliding gate, Wireless control system, Microcontroller, DC Motor, Magnetic switch*

INTRODUCTION

Back in the years, gates were being opened using human applied force in almost all over the world. These types of gates are known as manually controlled gates. These gates are still appreciated but in terms of effort and efficiency. Manual gates brings about a lot of challenges especially the sliding type.

In Nigeria and other developing countries, A manually sliding gate brings about the application of large human force to be applied during opening and closure. It also brings about large amount of friction between the rollers and the metal which the rollers rolls upon, it also brings about unwanted noise which is as a result of

the rollers made of metals. Due to these factors, there has been advancement in gate creation which is known as an automatic gate or electronic operated gate.

Swing gate

A swing gate is a gate usually in pairs that opens or closes sideways in its trajectory. Campbell and Toliyat (2015) designed an automatic swing gate using passive infra-red sensor. The gate designed with the aid of the passive infra-red sensor is specific in detecting the presence of a human being before opening. The swing operator used in this gate requires more space for its operation and could prove to be problematic in steep landscapes.

Sliding gate

A sliding gate is a fence that can be rolled to one side to allow entrance or a type of gate designed to roll horizontally alone a track on grooves parallel to the vicinity wall. This type of gate is usually employed where there is a limited open space for swing or foldable operated gate. It can be designed to operate electronically either by delay timing, wired or wireless controlled system

METHODOLOGY

Components used in the design

Electronically, the prototype gate with a wireless control system is designed in such a way that the load always matches with the power source so that it can function effectively. These components include:

1. Arduino Nano
2. Stepper motor 28BYJ-48
3. Motor Driver ULN2003 Module
4. Casing wood MPF wood
5. Remote control
6. UH/RF Wireless module
7. Connection wire jumper
8. Resistor 10k
9. Capacitor 4.7uF 16v
10. Transistor Bc547
11. Gear wheel and rack Plastic

Calculation analysis

This section deals with the actual calculation used to obtain parameter for the design. All components used in the construction were sourced locally and adequate

adjustments were made on all available substitute components in order to achieve the best result of the device under construction.

DC Motor selection

One of the most important laws of physics is the fundamental Ohm's Law. It states that current through the conductor is directly proportional to applied voltage and is expressed as:

I = V / R *where* I = current, measured in amperes (A);

V = Applied voltage, measured in volts (V);

R = Resistance, measured in ohms (Ω).

The needed current and voltage are I = 1.5Amp and V = 5volt respectively

Therefore,

R = V/I

R = 5/1.5

R = 3.33

R = 3Ω

Therefore the resistance of the motor is about 3 ohms

The consumed electrical power of the motor is defined by the following formula:

P*in* = I * V *where* P*in* = input power, measured in watts (W);

I =current, measured in amperes (A);

V = applied voltage, measured in volts (V).

Power consumed by the motor Pin =I*V

P*in* = 1.5*5

P*in* = 7.5

P*in* is approximately 8watt

Motors supposed to do some work and two important values define how powerful the motor is. It is motor speed and torque. Output mechanical power of the motor could be calculated using the following formula:

P*out* = T* ω, *where* P*out* = output power, measured in watts (W);

T =torque, measured in Newton meters (N*m);

ω =angular speed, measured in radians per second (rad/s).

But P*out* = 6.4 at 80% efficiency of the motor and the angular velocity was measured to be 0.008rpm, therefore

T = P*out*/ ω

T = 6.4/0.008

T = 800

This calculation was summarized with assumed negligible or zero friction

Gear rack selection

Gear disk and gear rack was selected with matching tooth and compatibility. The gear disc area is given by:

$A_{d} = 2\pi r^{2,}$ where r =2cm

$A_d = 2*\pi*2^2$

$A_d = 25.135$

$A_d = 25cm^2$

The area of the gear rack bar $A_r = 4*A_d$

$A_r = 4*25$

$A_r = 100\ cm^2$

This means the gear disk would revolve about 4 times to completely scroll the gate either in opening or closing direction

Resistors selection

10k resistors were used to reduce the collector current and to obtain an inverted signal from the transistors.

Capacitors selection

The 4.7uF capacitors were used for signal coupling and to block constant DC flow from the multiplexer circuit to the microcontroller.

Microcontroller selection

The microcontroller (Arduino Nano) was used for portability and circuit minimization as it occupy less space and also for it availability. Nano is a small, complete, flexible and breadboard-friendly Microcontroller board, based on ATmega328p, developed by Arduino.cc in Italy in 2008 and contains 30 male I/O headers, configured in a DIP30 style and therefore has the following features:
Arduino Nano Pin-out contains 14 digital pins, 8 analog Pins, 2 Reset Pins & 6 Power Pins. It is programmed using Arduino IDE, which can be downloaded from Arduino Official site. Arduino Nano is simply a smaller version of Arduino UNO, thus both have almost the same functionalities. Arduino Nano comes with a crystal oscillator of frequency 16 MHz It is used to produce a clock of precise frequency using constant voltage.

Microcontroller:	ATmega328
Operating voltage:	5 V
Input voltage (VIN):	6-20 V
Power consumption:	19 mA
Flash memory:	32 KB (of which 2 KB is taken by boot loader)
SRAM:	2 KB
Clock speed:	16 MHz
EEPROM:	1 KB
Current per I/O pin:	40 mA (20 mA recommended)
PCB size:	18 x 45 mm
Weight:	7 g
Connector type:	micro USB Type-B or C.

Major steps involve in the realization of this study entails sketching a detailed plan of the gate in form of block diagram, joining the pieces of word together to form the gate, calculating the exact power requirement of the electric motor, analysis of gate roller frictions, the required torque and the range of communication.

Block Diagram

The block diagram is a sketch representing sub-system interconnection and signal flow direction forming the main system. In this aspect there are two major sub-systems due to the wireless principle employed; these are the transmitter and the receiver unit.

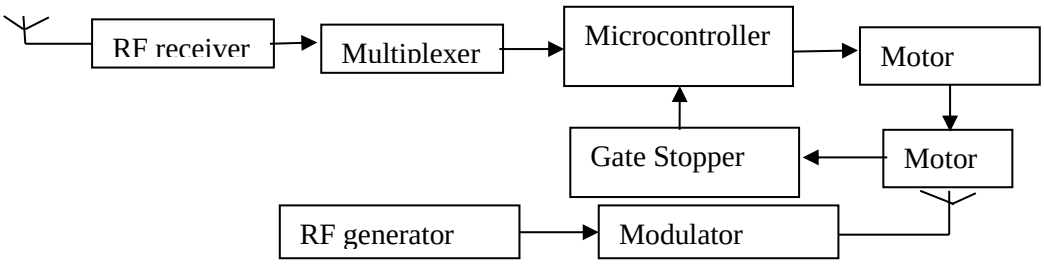

Fig 1: The block diagram of the sliding gate

Circuit Diagram

The circuit diagram is a drawing that shows the interconnection between components and the signal flow as it usually drawn from left to right. Sometimes, a circuitry may be in-chipped into a module were in connection pins floats for easy connection to the rest of the circuit components.

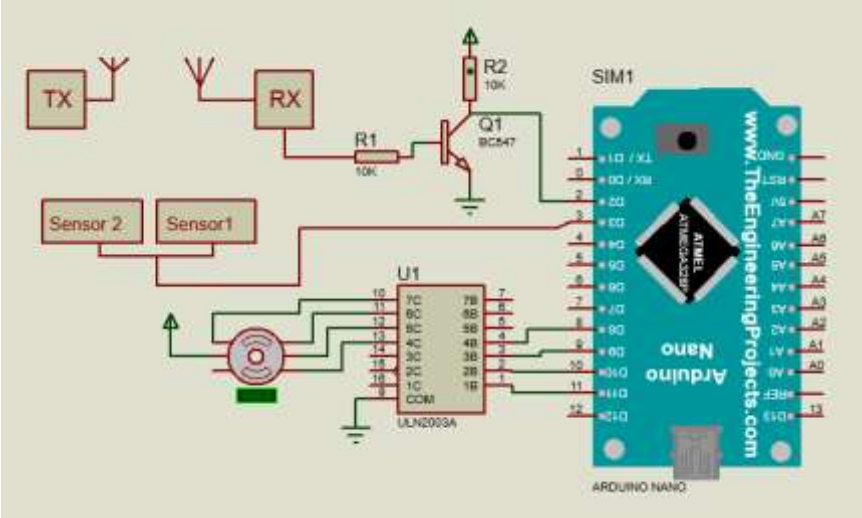

Fig 2: The schematic diagram of the sliding gate

Construction of the prototype sliding gate

The step by step approach taking in the implementation of this design started with the building of the gate frame with wood, followed by fixing of rollers, horizontal bar, gear racks, magnetic sensors, light emitting diode indicator and direct current motor.

Tools and instruments used:

- Lead and Soldering Iron
- Lead sucker
- Copper stripping knife
- Cutter
- Razor blade
- Plier
- Digital Multi-meter
- Vero and bread board

RESULTS AND DISCUSSION

Implementation

To conform to the requirement of this exercise, temporary construction of the prototype was done on bread board before finally transferring it onto the Vero-board for permanent soldering. The circuit was constructed, tested and put to use

under proper load conditions. In other to achieve accuracy in the design, some necessary adjustments were made to some of the components used.

Casing

This is the final finishing of the work, it is the external frame of the developed project which is visible and decorative with shape and color to suit the user. The casing was design with wood having a thickness of one inch, cut at different shapes and angles.

Fig 3: The front view of the finished prototype sliding home gate with a wireless control system.

Testing

While constructing, all components used were tested to ascertain their conformity with the required standard to the objective of this design. The output voltage of the inverter was a square wave, filtered by a 2μF/400V capacitor connected across the output terminals to remove the unwanted harmonics and leaving smooth sine waveform output voltage. The gate rolls on the horizontal metal edge at a speed of 3cm/s in the opening direction on the first signal reception and to closing direction on the second signal direction.

CONCLUSION

With appropriate approach, Research was carried out on the prototype automatic sliding home gate with a wireless controlled system and was implemented by ensuring that components connection, circuit sub-unit, and also the bread-boarding of this design were carefully carried out with due procedure. The prototype home

gate was designed, the wireless RF transmitter and receiver circuit and the control circuit were constructed, Programmed and the finished designed was tested. Result did not only show the quality of the work but also the expected efficiency together with it benefit to the society.

RECOMMENDATION

1. The project can be enlarged into a real gate using better material other than wood.
2. Camera can be attach through which the home owner can identify incoming guest before he can allow them in or the camera can be used for face recognition as another accessibility other the RF remote.
3. An Infrared scanning mechanism can also be in-chipped into the gate to improve home security.

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