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Solenoid as a wheeled KRSBI robot kicking mechanism

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ABSTRACT

Some types of kickers used are kicker mechanisms using spring, pneumatic, and solenoid. One of the uses of the magnetic field is to use a solenoid as a kicking mechanism in a robot, the magnetic field generated from the solenoid is able to move the plunger or iron core, designing the tool using copper weighing 2 kg. The problem faced is that the kick is not far away and the effects of the electromagnetic field generated from the solenoid can interfere with the electronic system on the robot. In this study, making a solenoid with the middle dimensions on the solenoid to 41 mm and the diameter of the plunger to 38 mm and using a cover with an iron faraday cage method with a thickness of 2 mm to minimize the magnetic field generated from the solenoid. In this study, the mechanism solenoid consists of 1 mm enamel wire and has a copper winding with a total of 1210 windings, in the power supply of a 12V Li-Po battery which is stepped up in its voltage to 400V and stored in a capacitor using a capacity of 5600 μF. By applying a solenoid voltage of 400V and a current of 4 A and being able to produce kicks with a distance of more than 6.68 meters, the height of which is able to pass through obstacles or obstacles.

1. Introduction

The Robo Cup Middle Size League (MSL), as one of the founding elements of the world robot cup, has been around since 1997. The game is played on a small indoor or indoor court. One team consists of 5 robots that are fully autonomous, and compete with other teams. Wheeled KRSBI is a soccer robot division that uses wheels as propulsion. And using a field consisting of a green carpet and two white goals. The kicking mechanism on the robot plays an important role in scoring goals when the robot competes. In wheeled soccer robot matches the more goals scored the greater the chance to win the match. Types of kickers on wheeled robots such as kickers using solenoids, pneumatics, and springs or springs.

Solenoid without cover with a diameter of 30 mm and plunger diameter of 30 mm [1]. the distance of the kick that is not far enough and the effect of the electromagnetic field generated from the solenoid kicking mechanism can interfere with the electronic system of the robot, so how to produce a kick with a distance of more than 4 meters and can minimize the effect of the electromagnetic field from the solenoid. The addition of an iron cover to the solenoid serves to minimize the magnetic field generated by the solenoid [2]. In this research, the center diameter of the solenoid kicker mechanism is 41mm and the plunger diameter is 38mm and the solenoid cover is added using an iron plate with a thickness of 2mm. for the pneumatic kick system uses a compressed air tank as a power source to generate the kick. This mechanism is the simplest of the three kicking systems as it only has a pneumatic valve connected to the fuel tank, and the valve is controlled to select when to fire [3].

A spring-based kicker where the kicking system uses a motor to generate mechanical force to compress the spring and store energy by locking the system in a high energy state [4]. The kicking mechanism consists of a solenoid supported by an iron frame so that it can be attached to the robot body. The solenoid is made of 0.8mm diameter enameled wire wound around a 1.25 inch diameter PVC pipe. Part of the electromagnet kick system is specially designed with high impact force. consists of a solenoid, electromagnet core, levers, capacitors [5]. Solenoids are manufactured using a non-variable magnetic circuit which consists of a fixed magnetic circuit and a magnetic iron bullet surrounded by a loop and requires a large capacitor (4700 F) to discharge across the coil to generate high currents which generate a magnetic field [6].

Solenoid is an electromagnetic device that can convert electrical energy into movement energy. The movement energy generated by the solenoid is usually only a push and pull movement [7]. Solenoid voltage comes from a DC to DC booster to provide a higher output voltage than a low input voltage [8]. uses the principle of the Lorentz force to accelerate the plunger by means of a plunger accelerator which consists of one or more coils used as an electromagnetic force to accelerate ferromagnetic or catapult projectiles at high speed [9]. A solenoid that is supplied with a high voltage to produce a large current. This current will produce a magnetic field that can push an iron plunger which in turn moves the rocker arm [10].

2. Research Methods

2.1. System Design

There are several parts to this kicking mechanism, the first part is the solenoid and the voltage riser or step up, the second is a capacitor to accommodate voltages up to 400 volts, the third part is the microcontroller electronic system as the control system.

In Fig. 1 is a block diagram of the kicking mechanism using a solenoid, there are several sensors used in this kicking mechanism. The sensors are Infrared sensors, voltage sensors and 2 channel relay modules. Infrared sensors function as triggers or triggers for activating the relay module. And the voltage sensor is used to read the voltage on the battery and capacitor contained in the kicker mechanism, while the relay module functions to activate the solenoid and charge the capacitor automatically, which is controlled using Arduino nano.

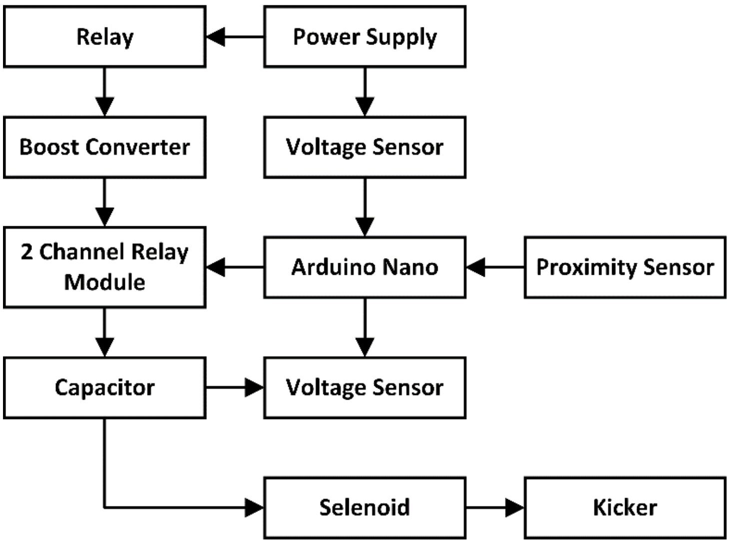

Fig. 1. System block diagram

The design of this tool includes the design of the Hardware wiring diagram in Fig. 2, which is the wiring harness for this tool, there are sensors used. The sensor is an Infrared sensor, and a 2 channels relay module. Infrared sensors function as triggers or triggers for activating the relay module. While the relay module functions to activate the solenoid and fill the capacitor automatically, which is controlled using Arduino nano.

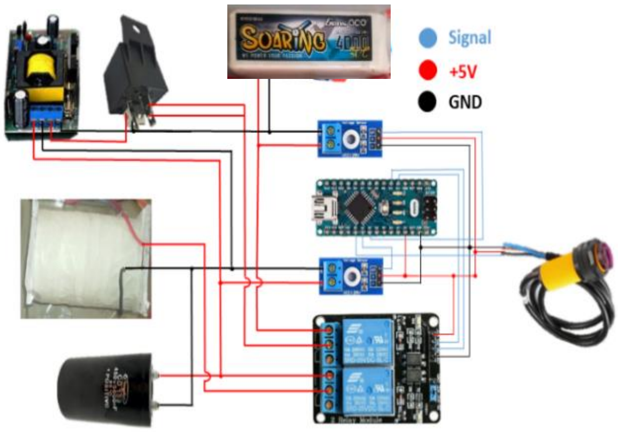

Fig. 2. Wiring cabling on the tool

Can be seen in Fig. 3, there is a block diagram of the tool, the workflow is that the 14.8 V battery power supply goes to the Booster, the booster increases the voltage from 14.8 V to 400 V. then the booster output goes to the capacitor to store the voltage from the booster output. then when the Proximity or infrared sensor detects an object, Arduino Nano will activate a relay to connect the capacitor to the solenoid. When the solenoid is active, the plunger will move because of the magnetic field generated by the solenoid.

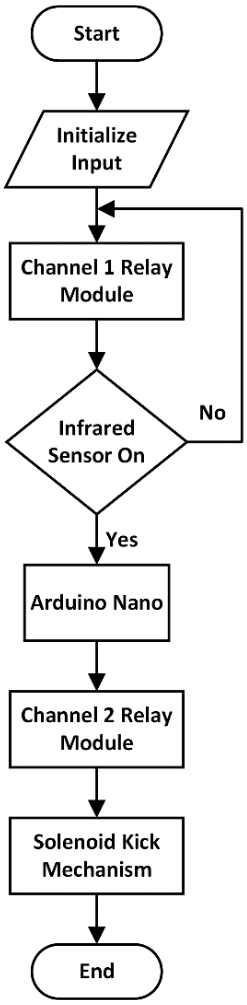

Fig. 3. Block Diagram of the kicker using a solenoid

2.2. Tool Design

Solenoid design on this kicker uses an aluminum plate with a thickness of 2 mm as a cross section, the area of the circle is 41 mm in diameter, the length of the solenoid is 10.5 cm, and has approximately 1210 copper turns with a diameter of 1 mm. The solenoid is also covered with a 2 mm iron plate which functions to Minimizes the effect of electromagnetic fields on the solenoid.

In Fig. 4 is the design of the kicking mechanism that uses the Solidwork application, this mechanism also has a total weight or mass of 3.841 kg.

Fig. 4. Hardware design

Fig. 5 is a prototype of the solenoid kick mechanism. This tool uses a 4 cell li-Po battery as a power supply. boost converter as a voltage booster, 400V capacitor with a capacitance of 5600 uF which functions to temporarily store the output from the booster, 2 channel relay module to activate the capacitor to be filled with voltage from the booster and when the solenoid is activated. the infrared sensor functions as a trigger or trigger to activate the solenoid which is controlled by the Arduino nano.

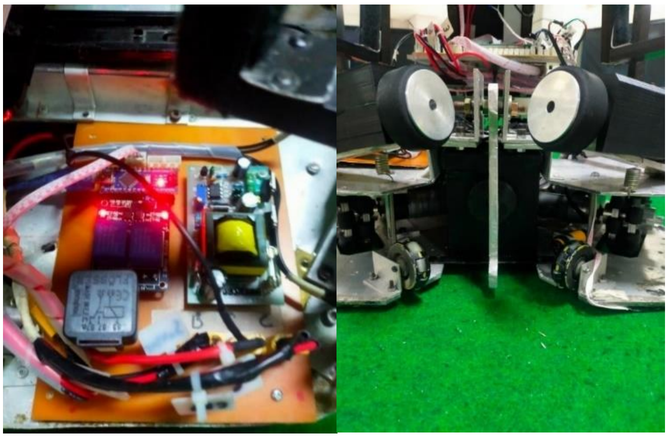

Fig. 5. Prototype of the solenoid kick system

The 4 cell li-Po battery is connected to the boost converter input, then the voltage is increased to 400v, and stored in the capacitor, when the infrared sensor is active as a trigger, the Arduino nano processes the relay module, to activate the solenoid, for the voltage sensor is used to read the value of the voltage on batteries and capacitors.

2.3. Evaluation Performed

This solenoid kick mechanism, the diameter of the cylinder section is enlarged to 41 mm and the plunger iron core is 38 mm in diameter and has a length of 25 cm, and adds a tubular iron cover made of iron plate with a thickness of 2 mm, which functions to focus the magnetic field generated by the solenoid. And compare the results of kicks using a 14 cm lever with a 11 cm lever.

3. Results and Discussion

3.1. Testing on the Solenoid

This test is carried out to check the circuit on the kicker module is connected correctly and the components work properly without any problems. This test was carried out several times to get the results of the resulting voltage, current, and power values.

It can be seen from Table 1 this kicking mechanism uses a voltage of 400 V and an average current measured on an ammeter of 4.34 A. resulting in an average power of 1723.2 watts. Fig. 6 shows the measurement results of the voltage and current in the kicking mechanism.

Table 1. Result of the speed of the ball kicked

No	Voltage (V)	Current (A)	Power (Watt)
1	400	4.32	1,728
2	400	4.34	1,736
3	400	4.27	1,708
4	400	4.31	1,724
5	400	4.30	1,720
$\sum$	20,000	21.54	8.616
$\bar{x}$	400	4.308	1723.2

Fig. 6 shows the measured voltage and current measurements on the solenoid kicker mechanism. It can be seen that the measured voltage on the multimeter and ammeter is 400 V and the measured current is 4.34 A.

Fig. 6. Voltage and current in the solenoid kick mechanism

3.2. Testing the Distance and Speed of the Ball

This test was carried out to find out how fast the ball was kicked from when the ball was kicked until it touched the floor.

3.2.1. Levers with a Length of 14 cm

This test was carried out using a lever with a length of 14 cm. Table 2 shows that the average distance generated by the kicking mechanism using a solenoid is 6.68 m with an average speed of 8.64 m/s.

Table 2. Ball speed data when kicked

No	Distance (m)	Time(s)	Speed (m/s)
1	6.6	0.75	8.8
2	7.1	0.85	8.35
3	6.5	0.74	8.78
4	6.8	0.79	8.60
5	6.4	0.72	8.89
$\sum$	33.4	3.85	43.22
$\bar{x}$	6.68	0.77	8.644

In Fig. 7 is the result of a kick from the solenoid using a lever with a length of 14 cm. the distance of the longest shot produced is 7.1 m and the height of the ball when kicked when it has approached the goal is more than 75 cm, so that it can avoid obstacles or obstacles.

Fig. 7. Lever kick distance of 14 cm

3.2.2. Levers with a Length of 12 cm

This test was carried out using a lever with a length of 11 cm. In Table 3 it can be seen that the average farthest distance generated by the kicking mechanism using a solenoid is 6.3 meters with an average resulting distance of 5.96 m with an average speed of 9.496 m/s.

Table 3. Data on the speed of the ball when it is kicked

NO	Distance (m)	Time(s)	Speed (m/s)
1	5.6	0.54	10.37
2	6.1	0.64	9.53
3	5.8	0.62	9.35
4	6.3	0.70	9
5	6	0.65	9.23
$\sum$	29.8	3.15	47.48
$\bar{x}$	5.96	0.63	9.496

In Fig. 8 is the result of a kick from the solenoid using a lever with a length of 11 cm. the farthest distance of the kick is 6.3 m and the height of the ball when kicked when it has approached the goal is less than 75 cm, so the ball cannot avoid obstacles or obstacles. From the test results above, the kick produced by using a lever with a length of 14 cm is more optimal because it is able to produce a longer distance and sufficient height to pass an obstacle or obstacle.

Fig. 8. Levers with a length of 11 cm

3.3. Magnetic Field Measurement

This test was carried out to find out whether the solenoid when using an iron plate cover using the faraday cage method or not using it can minimize the value of the magnetic field that comes out of the solenoid. In this test it is carried out by measuring at the top and front of the solenoid using a magnetic meter as a measuring instrument for the magnetic field generated from the solenoid kicking mechanism.

In table 5 the measurement of the value of the solenoid magnetic field without using an iron cover with the highest value on the front is 188 Gauss with an average value of 177.6 Gauss and the magnetic field measured on the top side is 26 Gauss with an average value of 21.6 Gauss.

Table 4. Unshielded solenoid magnetic field values

No	Voltage (V)	Magnetic Field (G) From the Front	Magnetic Field (G) From Above
1	200	170	21
2	200	168	19
3	200	188	24
4	200	183	26
5	200	179	18
$\sum$	1000	888	108
$\bar{x}$	200	177.6	21.6

In Fig. 9, the measurement of the solenoid magnetic field using a magnetic meter can be seen that the measured value on the front side is 188 Gauss and on the top side is 26 Gauss.

Fig. 9. Value of the magnetic field on a solenoid without a cover

It can be seen in Table 5 of the measurement results on the magnetic field value using an iron cover with the highest value of 262 Gauss with an average value of 260.4 Gauss and a value measured from the top side of 6 Gauss with an average value of 4 Gauss.

Table 5. Solenoid Field Measurements using a cover

No	Voltage (V)	Magnetic Field (G) From the Front	Magnetic Field (G) From Above
1	200	257	3
2	200	265	6
3	200	258	4
4	200	263	4
5	200	259	3
$\sum$	1000	1302	20
$\bar{x}$	200	260.4	4

In Fig. 10, the measurement of the magnetic field of the solenoid can be seen that the measured value on the front side is 262 Gauss and the measured value on the top side is 6 Gauss.

Fig. 10. Solenoid magnetic field values using an iron cover

4. Conclusion

Based on the results of the research and discussion, it can be concluded that by designing the diameter of the solenoid to be larger and the length of the levers to be 14 cm, the resulting kick distance can be further and the height of the ball can pass through obstacles or obstacles. In the next experiment using an iron cover with a plate thickness of 2 mm can affect the value of the magnetic field in the solenoid. When using a magnetic field solenoid cover, the measured magnetic meter at the top of the solenoid is 6 Gauss, while the magnetic field value that is not using the cover is 26 Gauss. it is recommended to reduce the weight of the kicking mechanism using a solenoid so as not to overload the robot.

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