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Modification of Drivetrain and Control System Plastic Mulch Hole Puncher Vehicle

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ABSTRACT

A mechanical mulching becoming popular due to the shortage of labor [1]. Plastic Mulch Hole Puncher Vehicle have been developed from research about Design of a Remote Control System as a Semi-Automatic Plastic Mulch Hole Puncher [2] and Automatic Pest Spraying Vehicle Frame Design [3]. The drivetrain that has been developed uses 4 wheels so it can slip if it encounters muddy terrain. In this research, we modified the drivetrain like a tank so that the vehicle can move in all situations. In previous research, the control system used was Fly Sky Remote Control and Arduino MEGA to control the Plastic Mulch Hole Puncher. In this research, we modified the remote and controller using a pair of microcontroller and radio frequency modules. For the drivetrain, the method used in this research is a modification using a pair of chains with metal plates welded to each outer link and 4 sprocket for the left and right sides. The chains and sprockets used are for motorbikes, and the metal plates using ST37 with dimensions 60 x 15 x 3 mm. For the control system, the method used in this research is to combine data reception from the transmitter and actuator movement with Arduino UNO and nRF24L01 module. In vehicle, 11 Digital Pins of Arduino UNO connected to: nRF24L01 via adapter module, 2 BTS 7960 motor driver that connect to power windows motor for automotive use, and 2 relay module to drive 2 pneumatic DCV (Direct Control Valve) that connected with Mulch Hole Puncher. In transmitter, 7 Digital Pins of Arduino UNO connected to: nRF24L01 via adapter module and 2 push button for activated pneumatic DCV /Mulch Hole Puncher, meanwhile 2 Analog Pins connected to joystick for control vehicle movement (froward/backward, turn left/right). The results of this research, the vehicle can be driven using a new drivetrain and controlled by Arduino UNO and nRF24L01 using radio frequency.

***Keywords**: tank drivetrain, open-source microcontroller, radio frequency*

1. INTRODUCTION

A mechanical mulching becoming popular due to the shortage of labor. The machine mulching soils developed by department of machinery use and vocational training of the Kazakh National Agrarian University, performed well with average forward speed of 2,03 km/h [1]. But it using tractor to moved with the lowest speed, so it kept changing frequency of rotation of a cranked shaft of engine, as seen on Figure 1.

Figure 1. Test run of the machine for plastic mulching and planting vegetable seedlings [1]

In previous research of Pest Spraying Vehicle performed well and can hold the load of the components [3]. But the dimension is too big, and drivetrain uses 4 wheels so it can slip if it encounters muddy terrain, as seen in Figure 2.

Figure 2. Pest Spraying Vehicle [3]

A Remote Control System as a Semi-Automatic Plastic Mulch Hole Puncher have been develop, it used Fly Sky Remote Control and Arduino MEGA to control the system [2]. The output Fly Sky Remote Control receiver connected to Arduino MEGA to send signal for vehicle movement via motor driver and activate pneumatic DCV Plastic Mulch Hole Puncher via relay, as seen in Figure 3.

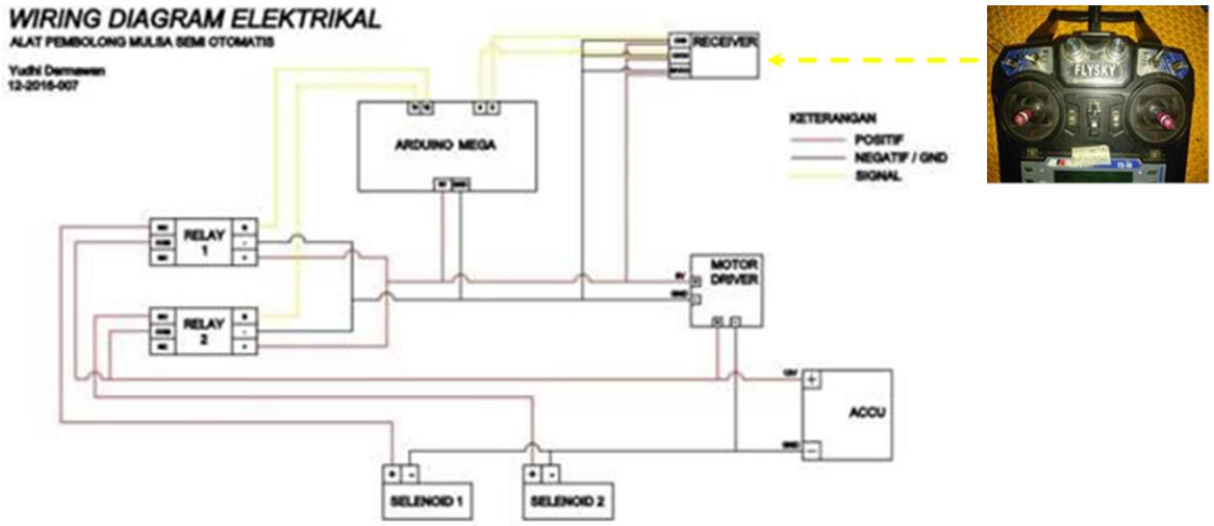

Figure 3. Wiring diagram Control System & Transmitter [2]

In the research of Unmaned Ground Vehicle Design (UGV) as an Observation Tool, the use of motorcycle chains and sprockets as drivetrain has been presented [4] (Figure 4). The actuator for UGV using power window motor that uses for automotive as seen in Figure 5. The motor is DC electric with 12 V and maximum current 7 A. It have maximum torque 30 kgf/cm and 70 rpm.

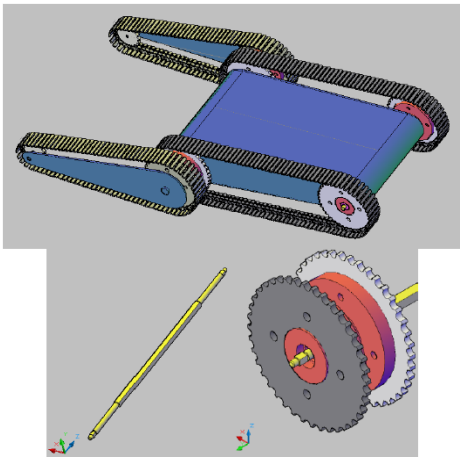

Figure 4. Wiring diagram Control System [4]

Figure 5. Power Window Motor as UGV actuator [4]

Based on selection of UGV control components, the Arduino UNO are the most suitable for this research. It has 14 Digital I/O with 6 PWM/Analog Output and 6 Analog Input (Table 1.).
Chain contains inner and outer link [5]. Simple outer link contains outer plates and bearing pins, as seen in Figure 6. In this research, the possibility of welding the metal plate is located at the outer plate.

Table 1. UGV control component selection [4]

Variabel	Smartrelay Zelio 	NI-DAQ USB – 6008 	Arduino UNO 	ChipKIT UNO32 
Jumlah I/O	16 (DI) 6 (AI) /10 (DO)	8(AI) / 2(AO) 12(D I/O)*	14 (D I/O) (6 PWM O) 6 (AI)	42 I/O 12 (AI) 5 (PWM)
Harga	± Rp. 1,75jt	± Rp. 2,7jt	± Rp. 285rb	± Rp. 400rb
Kehandalan	Tinggi	Sedang	Rendah	Rendah
Akusisi data	tidak	Ya	ya	Ya
LabVIEW support	tidak	Ya	ya	Ya

(National Instruments, 2005)

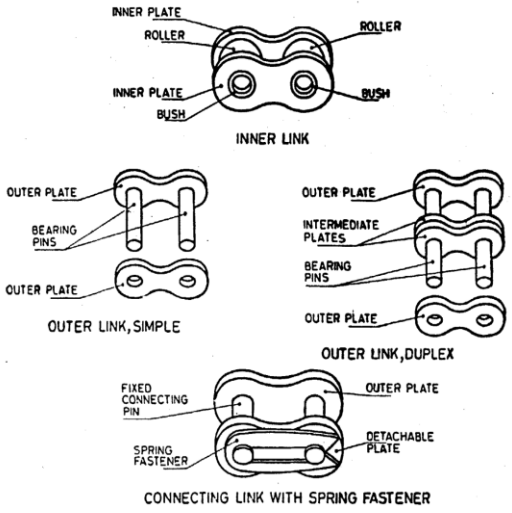

Figure 6. Nomenclature of Links [5]

The use of the nRF24L01 module has been carried out in various studies [6][7], as seen in Figure 7. Although the results have not been optimal, which shows a range between 20 to 40 meters.

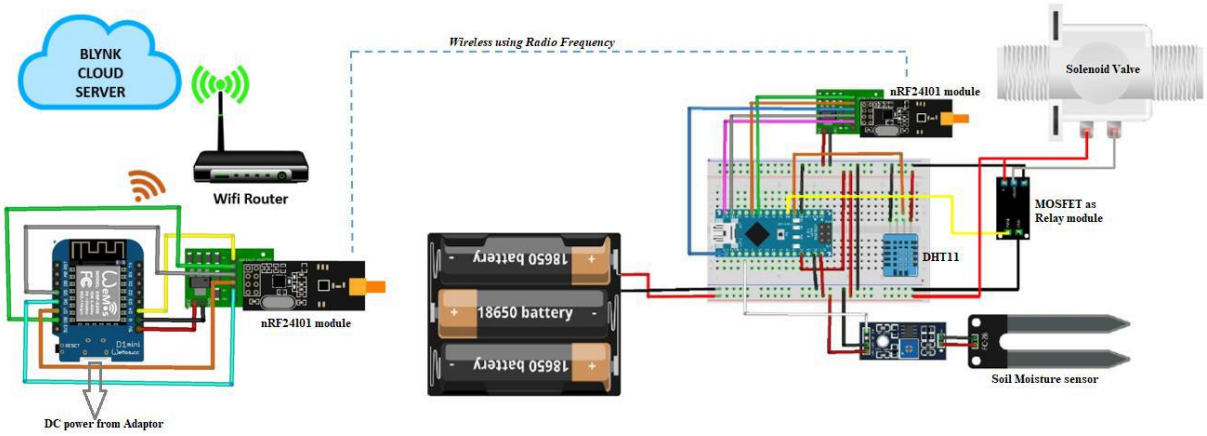

Figure 7. Wiring Diagram on Receiver and Transmitter side [7].

The constructed Plastic Mulch Punch Vehicle suffered damage due to welds between the metal plate and chain on the drivetrain, as seen in Figure 8. In this research, we modified the drivetrain like a tank, using a pair of chains with metal plates welded to each outer ring and 4 sprocket for the left and right sides, so that the vehicle can move in all situations. For the control system, we modified a remote control using a pair of Arduino UNO microcontrollers and an nRF24L01 radio frequency module to send, receive, and control actuator movements.

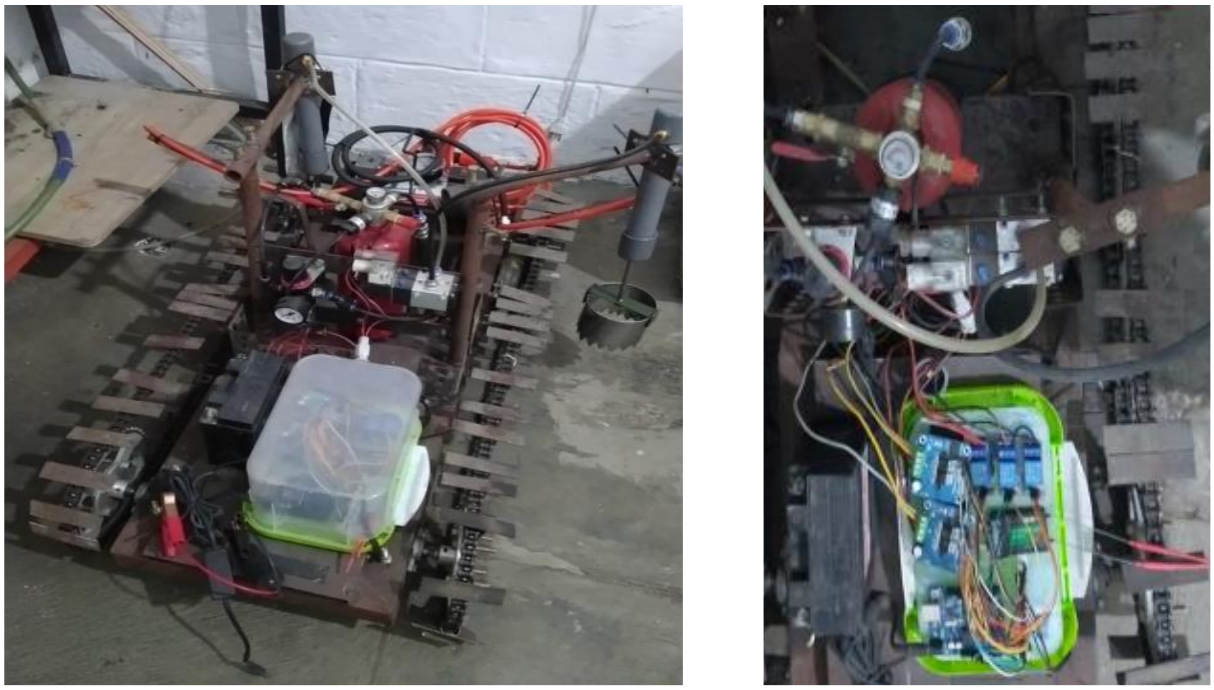

Figure 8. Modified Plastic Mulch Punch Vehicle

2. METODOLOGI

2.1 Drivetrain

Design of the drivetrain illustrated in Figure 9 and 10 consists of chain and sprockets for replacing the wheels and metal plates welded to each outer ring. The proposed drivetrain is meant to work in all terrain conditions.

The plates are welded using SMAW (Shield Metal Arc Welding). Metal plates using ST37 with dimensions 60 x 15 x 3 mm.

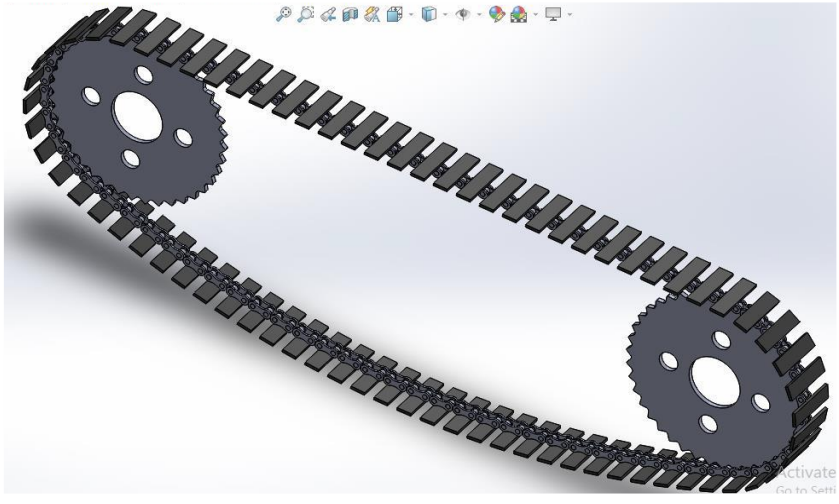

Figure 9. Design of drivetrain using chain and sprocket for motorbikes

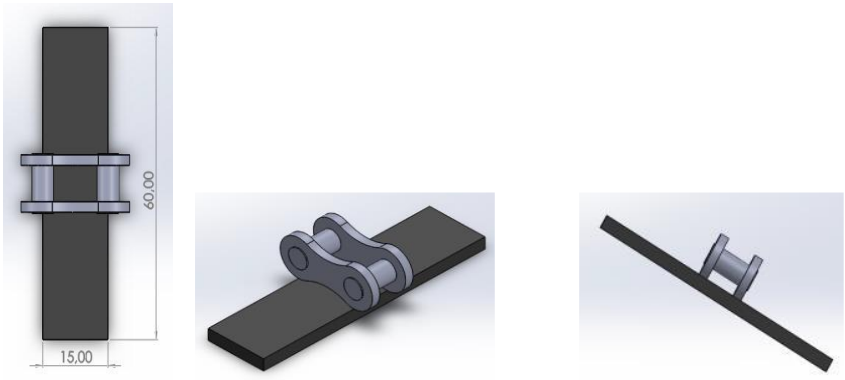

Figure 10. Design of metal plates welded on outer link

2.2 Control System

Design of the control system illustrated in Figure 11 and 12 consists of transmitter to remote operation and receiver and controller in vehicle. The transmitter and receiver using microcontroller and radio frequency module is meant to minimize the cost (Table 1) and components.

In transmitter, Arduino UNO connected to nRF24L01 via adapter module, 2 push button for activated pneumatic DCV/Mulch Hole Puncher, and joystick to control vehicle movement.

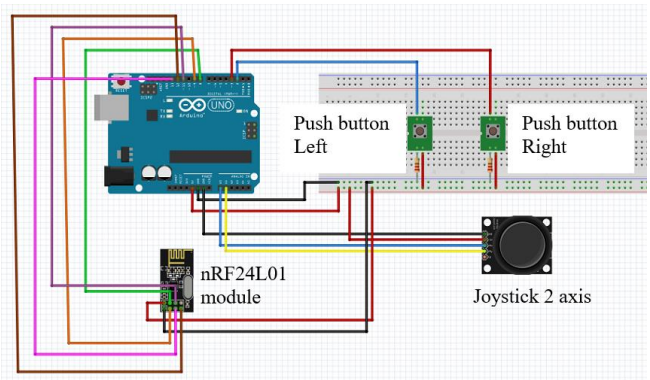

Figure 11. Design of transmitter using Arduino UNO and nRF24L01

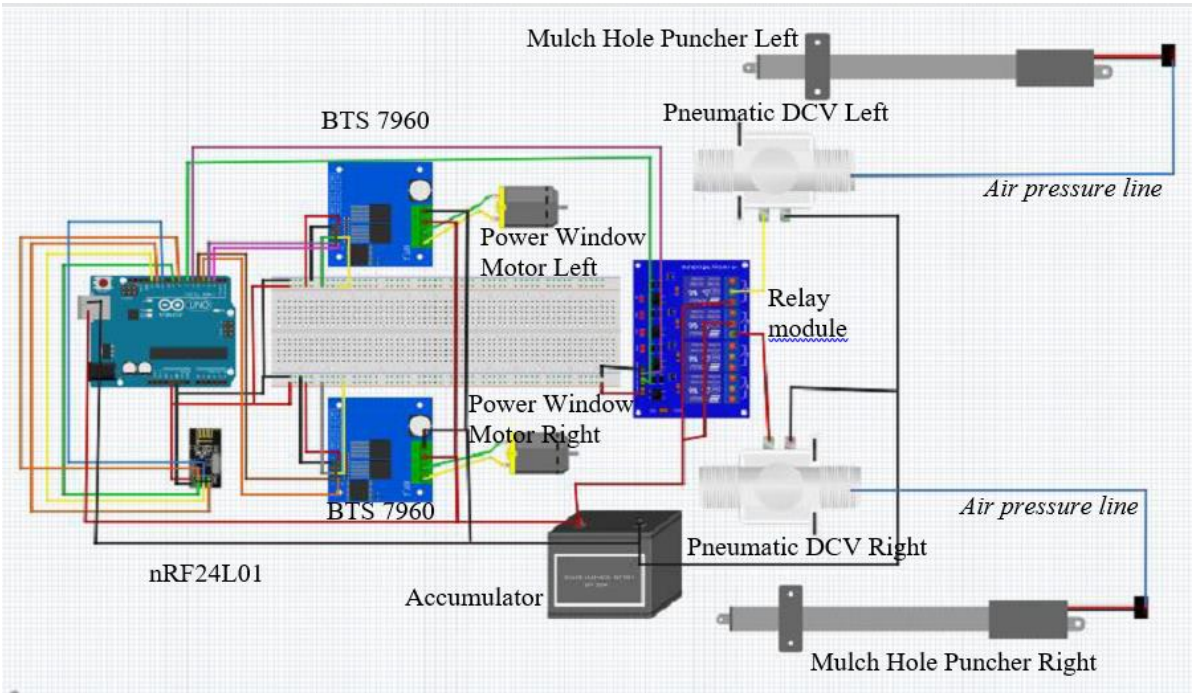

Figure 12. Design of receiver and controller in vehicle using Arduino UNO and nRF24L01

In receiver side on vehicle, Arduino UNO connected to nRF24L01 via adapter module, 2 BTS 7960 motor driver that connect to power windows motor, and 2 relay module to drive 2 pneumatic DCV that connected with Mulch Hole Puncher left and right.

3. RESULTS AND DISCUSSION

The result of drivetrain as seen in Figure 13, a pair of motorcycle chains and 4 sprockets were used for the drivetrain with metal plates welded on each outer chain link using ST37 material with dimensions 60 x 15 x 3 mm.

Figure 13. Modification result of drivetrain Plastic Mulch Hole Puncher Vehicle

The result of transmitter as seen in Figure 14, the joystick can move the vehicle froward/backward, and turn left/right, then the blue push button can activate the right Mulch Hole Puncher meanwhile the black push button can activate the left Mulch Hole Puncher. In transmitter, 7 Digital Pins of Arduino UNO connected to: nRF24L01 via adapter module and 2 push button for activated pneumatic DCV /Mulch Hole Puncher, meanwhile 2 Analog Pins connected to joystick for control vehicle movement (froward/backward, turn left/right).

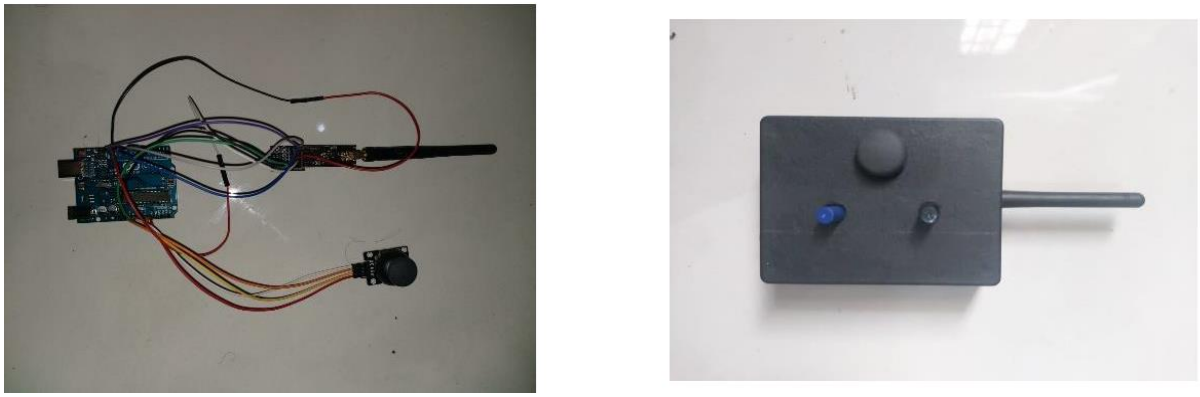

Figure 14. Transmitter for Plastic Mulch Hole Puncher Vehicle

The result of receiver in vehicle as seen in Figure 15, 11 Digital Pins of Arduino UNO connected to: nRF24L01 via adapter module, 2 BTS 7960 motor driver that connect to power windows motor for automotive use, and 2 relay module to drive 2 pneumatic DCV (Direct Control Valve) that connected with Mulch Hole Puncher. The Arduino UNO not only receives signals from the nRF24L01, but also controls the motor using a BTS 7960 motor driver and activates the pneumatic DCV using a relay module.

The modified Plastic Mulch Hole Puncher Vehicle can be seen in Figure 16, the receiver shown has a cassing to protect the components from dust or water, and the manufacture of the Mulch Hole Puncher which is then connected to the pneumatic system using an accumulator tank.

Figure 15. Receiver for Plastic Mulch Hole Puncher Vehicle

Figure 16. Modification result of Plastic Mulch Hole Puncher Vehicle

4. CONCLUSION

The new Plastic Mulch Hole Puncher Vehicle developed by department of mechanical engineering of the Institut Teknologi Nasional Bandung was tested on laboratory. The machine performed well, the drivetrain can make the vehicle move forward, backward, turn left and right. The Arduino UNO and nRF24L01 in transmitter side can send signals to move the vehicle and activate left and right Mulch

Hole Puncher. Meanwhile, the receiver side of the Arduino UNO and nRF24L01 can receive signals from the transmitter and also send signals directly to the BTS 7960 motor driver for vehicle movement and relays to activate the left and right pneumatic DCV.

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