Design locomotion for automatic guided vehicles using double ackerman inverted method (2WD-4WS-1A)

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Abstract. This paper introduces a robot vehicle designed for the same forward or reverse maneuver specifications. The vehicle has two two-wheel drives with a Double Ackermann Inverted (2WD-4WS-1A) steering method for Automatic Guide Vehicle (AGV). In the batch processing system industrial estate, AGV is used for transportation in the component warehouse area. In the steering system, Ackermann's mechanics are described as optimizing the maximum maneuvering radius of the AGV, based on the turning center point. AGV drive is designed with four wheels, two drives and one steering mechanics. The vehicle's mechanical steering system is designed with a system geometry analysis to control the turning radius of the vehicle. The Ackermann AGV steering method that has been implemented will be tested for its maneuvers. The results of the study were measured empirically to determine the efficiency and optimization of the system in the AGV design. The efficiency of steering control using only 1 steering wheel as 4 wheel control and small optimal radius on the AGV will increase maneuverability compared to using 2 WD.

1. Introduction
There is a growth and development progress in human life on technology towards automation. One of the identifications such as dirty, dangerous, and boring is something that is often encountered [1]. The introduction of robots, flexible programming can simplify various repetitive tasks in various conditions. Although the history of industrial robots can be traced back to the 1930s, the first industrial programmable robots are believed to have been commissioned by Unimation in the early 60s [2]. Better performance and stability appear to be at the forefront of the auto industry looking for unconventional approaches to power distribution and maneuverability. Four-wheel steering (4WS) is an advanced control technique that can improve characteristics. Compared to traditional two-wheel steering (2WS), the four-wheel steering system directs the front and rear wheels individually during cornering. Four-wheel steering can improve handling stability, increase active vehicle safety, and allow the vehicle to turn at a much smaller turning radius [3]. The ideal condition of the steering system can be approached by analyzing the Ackerman condition, which is a condition where the turning angle given by the driver to the steering wheel is the same as the turning angle experienced by the vehicle.
2. Literature review

2.1. Ackerman steering
Today most vehicles use a two-wheel steering mechanism as their primary handling system. However, the efficiency of the two-wheeler was shown to be lower [4] and the 2WS system requires more turning radius compared to the 4WS system which requires more space to turn the vehicle [5].

![Figure 1. Model 2WS 2WS [1,5,6].](image)

2.2. Four wheel steering
The 4WS is also called rear-wheel steering or all-wheel steering where the four-wheel symmetrical steering system as shown in figure 2. shows that the front and rear wheels outside and inside are turning at the same angle. So that this condition results in the shortest possible turning radius for the vehicle because the perpendicular lines of the wheels meet at the center line of the wheel base [5].

![Figure 2. Four Wheel Steering [5].](image)

3. Methods
The research method is basically a scientific way to obtain information with specific purposes and benefits. The steps in this research method can be seen in the research design in the following explanation:

3.1. Design of double ackermann inverted AGV locomotions
In this research, the manufacture of an AGV prototype consisting of 4 wheels, 2 motors forward and backward on the front side and a steering system to change the angle of the four wheels as a change in the direction of motion of the AGV. Angle the front and rear wheels in one command and reverse the polarity of the angle. Steering motor position in the middle of the longitudinal AGV, can operate optimally.
3.2. The AGV steering and chassis design
Steering is a mechanical control that is able to adjust the position of the wheels where the four wheels are set. Steering is designed in such a way as shown in figure 3. To maintain effectiveness and flexibility in controlling the position of the wheels of the wheel, several component parts composed of threads are used as rotating wheels. In addition, there are cylinder pistons and cross joints to help drive elasticity in the steering.

![Figure 3. AGV steering system models (2WD-4WS-1A).](image)

The frame design is made flexible in such a way as to minimize sleep on one of the wheels. So that it appears that one side of the wheel segment will be lifted if there is an uneven surface side.

3.3. Data collection method
The identification of the AGV steering uses a maximum limit with an angle of 30°, which uses the double ackerman inverted method. The results of the calibration are shown in the table below.

| Trial | Front Wheel Angle (deg) | Rear Wheel Angle (deg) |
|-------|-------------------------|------------------------|
| 1     | 0                       | 0                      |
| 2     | 5                       | -5                     |
| 3     | 10                      | -10                    |
| 4     | 15                      | -15                    |
| 5     | 20                      | -20                    |
| 6     | 25                      | -25                    |
| 7     | 30                      | -30                    |
In Table 1, it can be seen that the angles generated from the front wheel and rear wheel produce an inverse result from the position of the front wheel. The motor on the steering control adjusts the angle results obtained by the AGV.

4. Results and discussion

This test is carried out to identify, in graphical form, sensor signals, motor and steering drivers, current sensors and encoders. The test is carried out in a closed room with a tiled platform with the results below.

4.1. Round with 30° angle (PWM KA 50 and KI 25)

| V. Right IBT Conversion | V. Left IBT Conversion | V. IBT Steering Conversion | I. Right IBT | I. Left IBT | I IBT Steering |
|-------------------------|------------------------|----------------------------|--------------|-------------|----------------|
| 1 2.32                  | 2.48                   | 2.48                       | 1            | 0.1         | 0.12           |
| 2 1.97                  | 2.38                   | 2.46                       | 2.89         | 0.63        | 0.2            |
| 3 1.99                  | 2.41                   | 2.47                       | 2.74         | 0.48        | 0.18           |
| 4 1.97                  | 2.4                    | 2.47                       | 2.86         | 0.52        | 0.17           |
| 5 1.99                  | 2.41                   | 2.47                       | 2.77         | 0.49        | 0.17           |

The current used in the right motor driver (PWM Ka) produces a greater value than the left motor (PWM ki). In the table above the experiment uses PWM, with a right motor speed of 50 and a left motor 25 pwm. With a radius of 30° angle. Markers are used to mark the results of the AGV movement.
Figure 5. Response of a 30° angle radius on pwm Right 50 and Left 25.

With this radius, the results obtained with an AGV turning diameter of 2000 mm. Markers are used to mark the results of the AGV movement. Markers are used to mark the results of the AGV movement.

4.2. Round with 30° angle (PWM KA 100 and KI 25)

Table 3. Round identification with 30° Angle (PWM KA 100 and KI 25).

|     | V. Right IBT Conversion | V. Left IBT Conversion | V. IBT Steering Conversion | I. Right IBT | I. Left IBT | I IBT Steering |
|-----|--------------------------|------------------------|-----------------------------|--------------|-------------|----------------|
| 1   | 2.42                     | 2.47                   | 2.61                        | 2.61         | 0.44        | 0.16           |
| 2   | 2.41                     | 2.47                   | 2.62                        | 2.49         | 0.5         | 0.14           |
| 3   | 2.44                     | 2.47                   | 2.62                        | 2.49         | 0.5         | 0.15           |
| 4   | 2.44                     | 2.47                   | 2.65                        | 2.65         | 0.32        | 0.14           |
| 5   | 2.41                     | 2.47                   | 2.69                        | 2.69         | 0.49        | 0.15           |

The use of current consumption is directly proportional to the PWM used in both motors. In the table above the experiment uses a PWM with a right motor speed of 100 and a left motor pwm of 25. With an angle radius of 30°.

Figure 6. Response of an angular radius of 30 at AGV.

With this radius, the results obtained with the AGV turning diameter of 1800 mm. Markers are used to mark the results of the AGV movement. Markers are used to mark the results of the AGV movement.
4.3. Round with 20° angle (PWM KA 50 and KI 25)

| V. Straight IBT Conversion | V. Left IBT Conversion | V. IBT Steering Conversion | I. Right IBT | I. Left IBT | I IBT Steering |
|--------------------------|----------------------|--------------------------|-------------|------------|---------------|
| 1                        | 2.02                 | 2.47                     | 2.44        | 2.62       | 0.17          | 0.3           |
| 2                        | 2.01                 | 2.46                     | 2.44        | 2.65       | 0.22          | 0.3           |
| 3                        | 2                    | 2.46                     | 2.44        | 2.71       | 0.24          | 0.3           |
| 4                        | 2                    | 2.47                     | 2.44        | 2.71       | 0.19          | 0.3           |
| 5                        | 2.03                 | 2.45                     | 2.44        | 2.57       | 0.25          | 0.3           |

The use of current consumption is directly proportional to the PWM used in both motors. In the table above, the experiment uses PWM motor ka 50 and pwm motor ki 25. With a radius of 20°.

![Figure 7. Respons radius angle 20° pada AGV.](image)

With this radius, the results obtained with an AGV turning diameter of 2400 mm. Markers are used to mark the results of the AGV movement. Markers are used to mark the results of the AGV movement.

5. Conclusion

From the discussion and analysis that has been carried out in this study, it can be concluded, with an angle of 30° with the double Ackerman inverted steering method when the maneuver results in the turning radius of the AGV, it can be smaller when testing on the track. AGV with the double inverted (2WD-4WS-1A) method can operate optimally. The efficiency of steering control using only 1 steering as 4 wheel control and small optimal radius on the AGV will increase maneuverability compared to using 2 WD.

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