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EDITORIAL

Pembaca yang budiman,

Puji syukur kita dapat berjumpa kembali dengan Technologic Volume 13 No. 2, Edisi Desember 2022.

Pembaca, Jurnal Technologic Edisi Desember 2022 kali ini berisi 13 manuskrip.

Atas nama Redaksi dan Editor, kami do'akan semoga dalam keadaan sehat selalu, seiring dengan semakin menurunnya kasus pandemi covid-19, dan semoga di tahun 2023 semakin sukses dan berjaya, tak lupa kami haturkan terima kasih atas kepercayaan para peneliti dan pembaca, serta selamat menikmati dan mengambil manfaat dari terbitan Jurnal Technologic kali ini.

Selamat membaca!

DAFTAR ISI

DESIGN OF WIRELESS CONTROL SYSTEMS AND NAVIGATION SYSTEMS ON THE AUTONOMOUS VEHICLES AT HEAVY EQUIPMENT COMPANY

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Abstract - In this paper, the research development of the Autonomous Vehicle Prototype project has been carried out. The research was carried out on a golf cart (buggy) by designing wireless control and navigation systems. Designing a wireless control system on a golf cart aims to control the drive systems, steer systems, and brake systems. Furthermore, this system can be controlled electrically wirelessly through a Joystick Radio Controller, so that the golf cart can move forward, reverse, turn right and turn left. The navigation system aims to enable golf carts to track from point A to point B by using several sensors, including the GPS (Global Positioning System) sensor. GPS is used for tracking position on the golf cart, IMU (Inertia Measurement Unit) as a measure of the golf cart heading degree, LIDAR (Light Distance and Ranging) is used to detect distance and avoid obstacles, and Hall Effect Sensor as a speed sensor. The integration of the sensor and actuator systems is carried out using an Arduino Mega 2560 type microcontroller. Next, the movement from point A to point B is carried out autonomously. The final result of this research is that the GPS sensor can detect a track distance of 68.8 m with a minimum accuracy of 3 m and a resolution of 1 m. The IMU sensor can detect headings of 90º with 2º accuracy and 1º resolution. The LIDAR sensor can detect obstacles at a distance of 0 m – 4 m, and the Hall Effect sensor can detect the RPM of the car at a speed of 5 km/h. Golf cart control can be done wirelessly and automatically on the navigation system from point A to point B by avoiding obstacles.

Keywords: GPS, IMU, LIDAR, Wireless Control system, Navigation System, autonomous vehicle

I. *INTRODUCTION*

This research project is the first stage or the manufacture of a prototype on a light vehicle. From here it is hoped that it can be used as a POC (Proof of Concept) in the form of a vehicle that can operate autonomously on a track consisting of point A as the beginning to point B as the end with an object in the form of a golf cart. Golf carts include types of vehicles that are commonly used for transportation over short distances and are included in light vehicles. Unlike the AGV (Automated Guided Vehicle), the mechanism in this golf cart, there are several systems that work, including: the drive system as a speed control that controls a DC motor, the steer system as a steering control that controls the steering or steering control, and the brake system to apply braking which has done by pulling the brake pedal [1].

The first thing to do in this research is to make a wireless control so that the golf cart can be controlled easily by the user. Controlling in manual mode via a radio controller joystick when the user wants to test one of the systems and facilitates the next stage.

In this system there are three controlled systems, namely the drive system, steering system, and brake system. In the wireless control drive system, the system controls the speed of the DC motor through one of the channels on the joystick radio controller. In the wireless control steer system, the system controls the rotation of the steer through a DC steer motor with an absolute encoder input. To obtain a proportional rotation, PID is used in the control. Then, in the wireless control brake system, the system controls the DC motor brakes, so that electrical braking can be done. Next, create a navigation system. For this system, several sensors are used, including GPS, IMU, LIDAR and Hall Effect Sensors which are used when the car is navigating on a predetermined track point A to point B. For the wireless control and navigation system to be integrated with each system on the unit, the Arduino Mega 2560 microcontroller has used as a controlling device. It is because it is open source. In connection with this research, we have reviewed several related studies although different from various aspects. Among them carried out by Pan Zhao, et al, Ahmed Mohsen Kamel, et al, and Tagor Hossain, et al. [2, 3, 4]

II. *METHODOLOGY*

2.1. *Basic Theory*

2.1.1. *Autonomous Vehicle*

Autonomous Vehicle or an autonomous vehicle is a vehicle that can control itself without any human *intervention. An autonomous vehicle is also known as a driverless, robotic vehicle, self-driving vehicle, or autonomous car. An Autonomous vehicle uses several kinds of technology in its operation. Autonomous vehicles can use GPS to assist in navigation. In addition, other types of sensors or equipment may be used to avoid accidents. An Autonomous vehicle is also usually equipped with a distance-measuring sensor to avoid obstacles.*

2.1.2. ***Golf Car***

The golf cart is a type of light vehicle with dimensions that are not too large, which is designed with its main function, namely, to transport one or more golf players around a golf course with grassy or sandy terrain, making it easier to mobilize compared to walking. Golf carts are made to carry only a small number of passengers over a short distance and at a speed of just under 24 km/h. Generally, golf carts have dimensions of 1.2 m x 2.4 m x 1.8 m and weigh around 410 kg to 450 kg. Most golf carts are powered by electricity sourced from an accumulator of 24 VDC, but now many golf carts are also found with gasoline fuel sources.

2.1.3. ***Universal Asynchronous Receiver Transmitter***

Universal Asynchronous Receiver Transmitter or UART is a communication protocol commonly used in sending serial data between devices with one another by translating between parallel data bits and serial bits. In UART communication, There is only one master and slave, and two pins are required to transmit data between two UARTs, i.e. the Tx (transmitter) pin of the transmitting UART to the receiving Rx (receiver) pin, the two UARTs communicate directly with each other. . The transmitting UART converts the parallel data from a controlling device such as the CPU into serial form, transmits it serially to the receiving UART, which then converts the serial data into parallel data for the receiving device. UART speeds are typically 9600 baud and can be increased up to 115200 baud.

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2.1.5. ***Inter-Integrated Circuit***

Inter-Integrated Circuit or often called I^2C is a communication standard that combines the features found in SPI and UART. With I^2C, two or more slaves can be connected to a master or even two or more masters that control one or more slaves. I^2C only uses two cables for transmitting between two devices, namely SDA (Serial Data) is used to send and receive data, and SCL (Serial Clock) is used to carry clock signals. I^2C is a serial communication protocol so the data sent is bit by bit over the SDA. I2C is synchronous communication, so the output bits are synchronized into sampling bits by a clock signal controlled by the master. I^2C has a standard speed of 100 kbps to 5 Mbps with an unlimited number of masters, and the maximum number of slaves is 1008.

2.1.6. ***Controller Area Network***

Controller Area Network (CAN bus) is a data series developed in 1980 by Robert Bosch GmbH for use in automotive applications [5]. CAN allows microcontrollers and electronic devices to communicate with each other without using a host computer with fast and reliable data transfer rates in an electrical environment that has noise at low costs and uses minimal wiring. In 1991 Bosch published a specification for CAN 2.0 which is divided into 2 formats: CAN 2.0 A is a standard format with an 11-bit identifier, and CAN 2.0 B is an extended format with a 29-bit identifier. In 1993 ISO released the ISO 11898 CAN standard, which was then restructured into 3 parts: ISO 11898-1 which covers the data link layer, ISO 11898-2 which covers the CAN physical layer for high-speed CAN (up to 1 Mbit/s), and ISO. 11898-3 which includes physical layer CAN for low-speed CAN (up to 125 kbit/s).

2.1.7. ***Arduino Microcontroller***

Microcontroller is a microprocessor system in which there are already: CPU, ROM, RAM, I / O, Clock, and other internal equipment that are interconnected and well organized by the manufacturer and packaged in a single chip that is ready to use. So, we just need to program the contents of the ROM according to the rules of use by the factory that made it. To make a control system of an electronic device can be done with or without a microcontroller. Microcontroller is used if the process being controlled involves complex operations be it arithmetic, logic, timing, or others that would be very complicated if implemented with discrete components. One of the *advantages of the microcontroller is the flexibility in assembling discrete components because it is done in software. The processor in the microcontroller performs instructions according to the software in its memory (ROM). The software is an assembler language which represents the codes (oPCode) which are translated and executed by the processor. The microcontroller itself is an integrated circuit in which the microprocessor, memory, I/O ports, and other peripherals are connected. The signal that is usually processed by the microcontroller is a digital signal, for analog signals it is necessary to convert using ADC (Analog to Digital Converter) to get an equivalent digital value, otherwise if you want an analog signal output from digital data, a DAC (Digital to Analog Converter) is needed. The internal circuit block of a microprocessor consists of: ROM, RAM, and Input/Output ports can also be equipped with several other peripherals such as UART, ADC, EEPROM, timers and others according to the specifications of the microcontroller.*

2.1.8. *Arduino IDE*

To program the Arduino board, we need the Arduino's built-in IDE (Integrated Development Environment) application. This application is useful for creating, opening, changing Arduino source code (Sketches, programmers call Arduino source code as "sketches"). Sketch is a source code that contains logic and algorithms that will be uploaded to the IC (Integrated Circuit) microcontroller (Arduino).

2.1.9. *Global Positioning System*

The Global Positioning System is a system for determining position and navigation globally using satellites. The system, which was first developed by the US Department of Defense, is used for military, civilian purposes, as well as mapping surveys and geographic information. The GPS system, whose real name is NAVSTAR GPS (Navigation Satellite Timing and Ranging Global Positioning System), has three segments: satellite, controller, and receiver or user. There are 24 GPS satellites orbiting the earth, with fixed orbits and positions (exact coordinates), of which 21 are actively working and the remaining 3 are in reserve. Satellites function to receive and store data transmitted by control stations. Stores and maintains high-precision time information (determined by the atomic clock on the satellite) and transmits signals and information continuously to the receiver from the user.

2.1.10. *Inertia Measurement Unit*

Inertia Measurement Unit or commonly abbreviated as IMU is a self-contained measurement system that measures the linear and angular motion of an object such as a vehicle. Measurements will be accumulated based on the time to determine the object's position, speed, orientation, and direction of movement.

2.1.11. *Light Detection and Ranging*

Light Detection and Ranging or LIDAR is an optical remote sensing technology that works based on laser technology, which uses the reflection of electromagnetic waves from the transmitted unit to measure distances [6]. The wavelength ranges from 0.78 um to 1 um. The performance of a LIDAR is determined by the intensity of the emitted laser beam. The intensity of the emitted is limited because as a safety for human vision, therefore a strong receiver and transmitter is needed. In this project, a LIDAR Leddar Vu8 type 48^0 x 3^0 will be used.

2.1.12. *Hall Effect Sensor*

Hall Effect Sensor or Hall Effect Sensor is a transducer type component that can convert magnetic information into electrical signals for further processing of electronic circuits. This Hall Effect sensor is often used as a sensor to detect proximity, detect position, detect speed, detect movement direction, and detect electric current.

2.2. *System Concept*

In developing this Autonomous Vehicle Prototype research project, the golf cart as an object used as a prototype can be controlled wirelessly manually and autonomously or automatically through an R/C (Radio Controller). In addition, the system is expected to be able to meet the following considerations:

1. *The system uses a microcontroller which is used as a process device*
2. *There are 2 modes on the R/C, namely manual and autonomous or autonomous or automatic. In manual mode, users can fully control the golf cart and in autonomous/automatic mode, the car can move automatically with track point A to point B.*
3. *The wireless control drive system can control the speed and direction of movement of the DC motor type KDS ZQS48-3.0B-T-GN1 as the main motor of the golf cart wirelessly manually via R/C and the emergency button can lay off the system, namely the KDS ZQS48-3.0 motor. B-T-GN1 stops and brakes.*
4. *The wireless control steer system can control the rotation of the steer through the steer motor so that the car tires can turn right and turn left wirelessly manually via R/C and can lay off the system via 2 limit switches, i.e., the main motor stops.*
5. *The wireless control brake system can pull the brake pedal on the car through the brake motor through the R/C so that when activated, it can lay off so that the*

brake on and the KDS ZQS48-3.0B-T-GN1 motor turns off so that the golf cart can stop.

6. *The sensors used are:*

• GPS data can be accessed, GPS has 3 m accuracy, 1 m precision, and can detect track distance,

• IMU can perform heading tracking with 2^0 accuracy, 1^0 precision, and can detect headings up to 90^0,

• LIDAR can access data, detect objects up to < 4 m and > 4 m, and

• Hall Effect Sensor. can calculate speed up to 890.51 rpm,

7. The Navigation System is capable of point-to-point tracking, starting from Point A for 30 m, then turning 90^0 to the left, and ending at Point B with a maximum speed of 10 km/h or 1781.02 rpm, and

8. In the electrical section, the source used is the accumulator. In the wireless control drive system, a voltage of 24 VDC is required, then in the wireless control drive system and a wireless control drive system, a voltage of 24 VDC is required.

2.3. *Golf Car Unit*

Based on the concept of the system, the prototype object used is a golf cart with a max speed of 21 km/h. This golf cart consists of three main systems, namely: drive system, steering system, and brake system. The drive system functions to control the speed of the KDS ZQS48-3.0B-T-GN1 DC motor as the main motor which can be done by pressing the accelerator pedal which is located under the steer with a source originating from the Trojan T-875 accumulator arrangement hereinafter referred to as accumulator 1. In the driver section, there are Electronic Motor Controllers that are used as DC motor drivers KDS ZQS48-3.0B-T-GN1. The pedal drive is connected and rotates a potentiometer that is connected to the Electronic Motor Controller which will then rotate the KDS ZQS48-3.0B-T-GN1 DC motor. On the drive panel, there is an ignition key that functions to turn on the unit. In addition to the ignition there is a button for forwarding / reverse mode which functions to adjust the direction of rotation of the motor forward (forward) or reverse (reverse), and beside the button, there is a battery voltage level indicator. The steering system functions to control the slope of the car tires which can be done by turning the steering wheel mechanically either clockwise (CW) or counterclockwise (CCW). The brake system is a system that functions to stop the car's speed by pressing the brake pedal which is located under the steering wheel so that the pedal pressing mechanism will be able to reduce the speed and the car can stop.

2.3.1. *Components Used*

Based on the explanation of sub-chapter 3.1 regarding the system concept, the devices used in this research include: Accumulator 1; Accumulators 2; Switches; Emergency Stop Button; Limit Switches; Mini Circuit Breakers; Buck-Boost Regulator DC-DC; Radio Control; Encoders; GPS; IMU; CAN Shield; LIDAR; Hall Effect Sensors; Arduino Mega 2560 microcontroller; Relays; H-Bridge Drivers; PWM to voltage module; DC Motor

2.3.2. *Work System Design*

Based on the system concept that has been explained related to wireless control and navigation system to control the movement of the golf cart, a working system diagram is made. Figure 1 shows a diagram of the working system of an autonomous system.

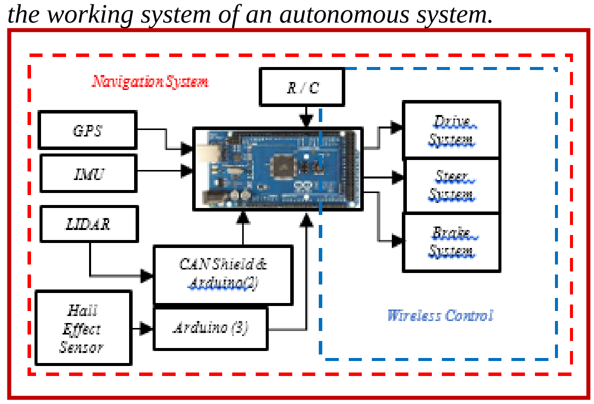

Figure 1. The Diagram of the working system of an autonomous system.

The work on the design of the work system on this autonomous vehicle is divided into two parts, namely wireless control, and navigation system. The working system uses Arduino Mega 2560. The system that is made first is wireless control, then the navigation system. Wireless Control is a system that functions to make the control drive system, steer system, and brake system on a golf cart from mechanical to wireless so that it can be controlled from an R/C (Radio Controller). The Navigation System functions to calculate speed, turning radius automatically, and retrieve data on each sensor when the car is tracking.

III. *DESIGN, TESTING, AND RESULTS*

3.1. *Component Layout Design*

The first stage of making electrical parts is to arrange the layout of the components used. Figure 2 shows the results of the layout design for the preparation of components and modules used.

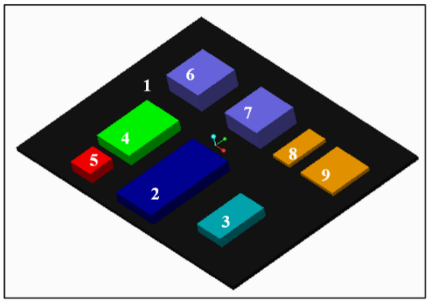

Figure 2. Component Layout Design

Description: 1. 3D printing base 2. Arduino Mega 2560 3. Buck Boost DC-DC Converter 4. 4x5 VDC Relay 5. PWM to Voltage Module 6. IBT-2 BTS79600 (Brake Driver) 7. IBT-2 BTS79600 (Steer Driver)) 8. 5 VDC Junction 9. 24 VDC Junction.

3.2. *Wireless Control Drive System Design*

The wireless control drive system changes the control of the drive system from being controlled mechanically and manually by the user by pressing the accelerator pedal to electrically and wirelessly using an R/C joystick control. Then for the car to run at varying speeds, a voltage controller is needed that enters the Curtis Electronic Motor Controllers driver, for this reason, this system is made using a PWM to voltage module which can output a voltage with a value that varies according to the PWM frequency value given by control via Arduino Mega 2560 instead of a potentiometer which has done mechanically. Then, this system converts forward and reverse control that is done mechanically into electrically via an R/C joystick. For safety, an emergency button has used so that the user can stop the control system if an undesirable situation occurs. In addition to those mentioned above, the design of a wireless control drive system is intended to facilitate integration with the navigation system at a later stage. Figure 3 shows the system drive design.

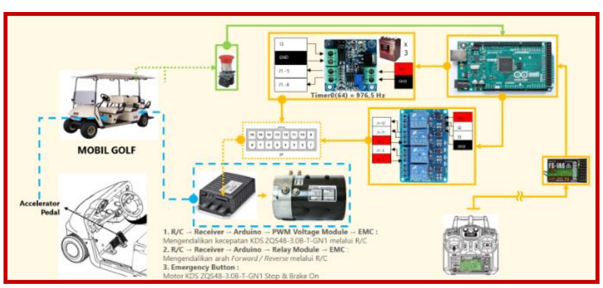

Figure 3. Drive system

The system drive diagram above explains how the system drive system works. The drive system voltage is supplied from an 8 VDC x 3 Trojan battery which is connected in series to produce an output voltage of 24 VDC which is then used as a source supply to the PWM to voltage module. PWM to voltage serves as a substitute for a pedal that provides analog voltage for the Curtis 1266 A/R Electronic Motor Controller. The PWM to voltage module will be controlled via the Arduino Mega 2560 microcontroller by providing a PWM signal. Furthermore, the Curtis Electronic Motor Controller will rotate the KDS ZQS48-3.0B-T-GN1 DC motor so that the golf cart unit can run according to the duty cycle of the PWM signal given to the PWM to voltage module.

3.3. *Navigation System Design*

Navigation System is a working system that functions to integrate the wireless control drive system, wireless control steer system, and wireless control brake system with navigation devices in the form of GPS, IMU, LIDAR, and Hall Effect Sensors. GPS is connected to Arduino using UART via RX and TX pins, IMU is connected to Arduino using I2C via SDA and SCL pins, LIDAR is connected using CAN Shield and Arduino to I^2C, and the Hall Effect Sensor is connected via an interrupt pin. Figure 4 shows a diagram of the navigation system.

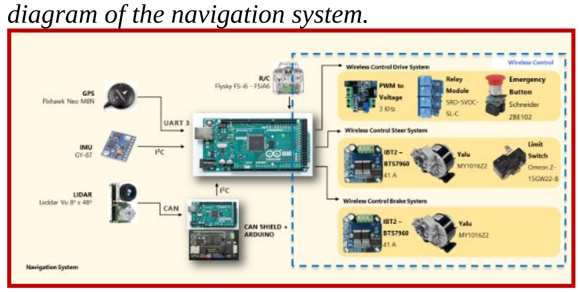

Figure 4. The Navigation System

3.4. *R/C Layout and Data Value*

In manual wireless control, the Radio Controller or R/C used is the Flysky FS-i6 type with access to up to 6 channels. The layout on the R/C Flysky FS-i6 can be seen in the image above. Channel 2 adjusts the input of the wireless control drive system and the wireless control brake system by moving the lever vertically. Channel 4 adjusts the input of the wireless control steer system by moving the lever horizontally. Channel 5 regulates the direction of the car going forward (forward) or backward (reverse). Channel 6 sets manual or automatic mode (autonomous/ automatic).

3.5. *Installation of Safety Devices (Limit Switch and Emergency Brake)*

Limit switches and emergency brakes are used as safety devices on the car so that if an undesirable *situation occurs, it can be stopped manually by the user. The installation of limit switches and emergency buttons uses the sourcing method and the input pin is set to pullup on the Arduino Mega 2560 and is installed with the NO (Normally Opened) method on the limit switch so that it is active when pressed, and the emergency button is installed with the NO method in parallel so that if both or one button is pressed, it can activate the emergency button.*

3.6. *Wireless Control Program Testing (Drive System, Steer System, and Brake System)*

3.6.1. *Wireless Control Drive System*

The Wireless Control Drive System Check Points include DC Motor Speed KDS ZQS48-3.0B-T-GN1 can be controlled; DC Motor KDS ZQS48-3.0B-T-GN1 Forward; DC Motor KDS ZQS48-3.0B-T-GN1 Reverse; and Emergency Button

3.6.2. *Wireless Control Steer System*

Wireless Control Steer System Check Points include Motor Steer (MY1016Z2) turn right; Motor Steer (MY1016Z2) turn left; Encoders; Left Wheel Limit Switch; and Right Wheel Limit Switch

3.6.3. *Wireless Control Brake System*

Check Point Wireless Control Brake System, including Motor Brake (MY1016Z2) on; and Pedal brake can be pulled

3.7. *Program and Testing Navigation System Sensors*

3.7.1. *GPS Pixhawk Neo M8N*

Pixhawk Neo M8N GPS Check Points, including GPS data in the form of latitude and longitude can be accessed; GPS has an accuracy of < 3 m; GPS has a precision of 1 m; and GPS can detect tracking distance

3.7.2. *IMU GY-87*

IMU GY-87 Check Points, including: IMU can access heading data; The IMU has an accuracy of 2^0; IMU has a precision of 1^0; IMU can detect headings up to 90^0.

3.7.3. *LIDAR Leddar Vu8x48*

Leddar Vu8x48 LIDAR Check Points, include LIDAR can access distance data; LIDAR can detect objects < 4 using one of the segments; LIDAR can detect objects > 4 m using one of the segments

3.7.4. *Hall Effect Senor Honeywell SNDH-T4L-G01*

Hall Effect Sensor Check Points Honeywell SNDH-T4L-G01, including Hall Effect Sensor can access rpm data; Hall Effect Sensor can calculate speed with a maximum speed of 10 Km/H or 1781.02 RPM

3.7.5. *Tracking Point A to Point B*

Checking point tracking from point A to point B, including Mode can be changed between Manual to Automatic; The car runs at a maximum speed of 10 Km/H or 1781.02 rpm; The car can turn when it detects an obstacle at a distance of < 4 m; The car can stop at Point B

3.8. *Analysis*

From the results of the wireless control test, the car's drive system can run when the input lever given to the R/C Channel 2 joystick is raised, then in the forward and reverse modes the car can move forward when the Channel 5 lever is raised or reverse when the Channel 5 lever is lowered, then when the emergency button is pressed the brake motor can turn on and dance on the brake pedal so the car can stop. Furthermore, in the wireless control steer system, the steer can rotate and can turn the tire to the right and to the left according to the input given to the joystick on Channel 4, then when the safety limit switches on the right and left tires are depressed, the car will automatically stop. Furthermore, in the brake system, when the Channel2 lever is lowered the brake motor can turn on then pull the brake pedal and the car can stop.

In the navigation system, evaluation is carried out on GPS, IMU, LIDAR devices, and sensors. On the GPS Pixhawk Neo M8N whether it can detect the distance accurately. On the IMU GY-87 can it detect the degree of inclination of the car accurately. On LIDAR LeddarVu8x48 whether it can detect obstacles. On the Hall Effect Sensor Honeywell SNDH-T4L-G01 can it read rpm speed and on tracking whether the car can track from point A to point B.

From the results of the tests carried out, the Pixhawk Neo M8N GPS can detect and display latitude, longitude, and distance data. However, this Pixhawk Neo M8N GPS has a noise at x of 18,8126192 m, and y of 9.56979112 m, so it cannot be an accurate distance detector. Then the IMU GY-87 can detect and display the degree of inclination of the car and the IMU GY-87 can only detect an angle of 92.16^0. Then the LIDAR LeddarVu8x48 has been able to display data on each segment and can detect obstacles at a distance of < 4 m using segment 4. Then the Honeywell Hall Effect Sensor SNDH-T4L-G01 can display rpm data with a value of 893.0196246 rpm at a speed of about 5 km/h and the difference of 3.0196246 rpm between the calculation results and the measurement results. Then on track, the car has been able to track from point A to point B by detecting obstacles with LIDAR at a distance of < 4 m and the IMU angle size is 92.16^0 and the difference is 2.16^0 from the requirement.

IV. *CONCLUSION*

In this paper, we have carried out the Design of wireless control systems and navigation systems on autonomous vehicles at a heavy equipment company. The Wireless Control system consists of a wireless control drive system, a wireless control steer system, and a wireless control brake system that can electrically control in manual mode with an R/C for forward, reverse, and turn movements. The sensors used in the navigation system have been able to perform tracking data. Among them: GPS Pixhawk Neo M8N, IMU GY-87, LIDAR Leddar Vu8x48, Speed Sensor Hall Effect Sensor Honeywell SNDH-T4L-G01. In this case, the golf cart can track in automatic mode at track point A, namely the access road to point B, with 68.8 m, speed of 5 Km/H (893.0196246 rpm), detection of obstacles at distance < 4 m, and the detection of the degree of the car's slope is 92.16^0*. Furthermore, we hope for further program development by the prototype function, namely, to mobilize goods from the warehouse to the manufacturing plant. In addition, it is also possible to replace some components with more accurate devices in other data retrieval.*

V. *ACKNOWLEDGMENTS*

We would like to thank the research team involved, both heavy equipment industry practitioners and Astra Polytechnic. Hopefully, the results of the discussion and implementation of this research will provide benefits for the development of industrial automation in Indonesia.

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