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UNMANNED ELECTRICAL GROUND VEHICLE CONTROLLER

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Research Article

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ABSTRACT: Without the need for a human driver, an Electric Unmanned Ground Vehicle (E-UGV) controller with a situational awareness system may travel on the ground either remotely or autonomously. For jobs involving surveillance and reconnaissance, a variety of sensors are available. For instance, they provide first responders up-to-date information regarding the state of affairs at the operation site. The goal of this project was to create a (EUGV) controller with a certain characteristic. With rechargeable batteries that last for two hours, the EUGV is a totally electrical vehicle with a GCS that manages its mission by gathering data from various sensors mounted on it and a video connection with a 4-kilometer range. There are two types of control: semi-automated and manual. Most significantly, a sensor system for obstacle identification and avoidance is also included in this study. This kind of controller's primary goal is to employ the Ground Control Station (GCS) to gather information, surveillance, and reconnaissance (ISR) functions to lower human danger in difficult terrain.

KEYWORDS: UGV, ZIGBEE, GUI, Wireless communication, SAS, Mini PC, Ground Control Station (GCS)

INTRODUCTION

Unmanned vehicle navigation has rapidly advanced in the field of robotics. An unmanned vehicle operates without a human being on board. Either an automated setup or a remote control system might be used to drive the vehicle [1]. The Association for Unmanned Vehicle Systems International (AUVSI) claims that unmanned vehicles are often used in both military and civilian and commercial contexts. Unmanned Ground Vehicles (UGVs) are unmanned land-based vehicles that carry out hazardous, dirty, or dangerous activities. Unmanned ground vehicles (UGVs) may find value in both civilian and security contexts, according to Abdelhafid B. et al. [1]. The usage of UGVs on a variety of surfaces, including smooth, rough, and level terrain, has been the subject of several studies [2]. Consequently, the challenging terrain surface was considered in these investigations. Omnidirectional refers to the ability to move in several directions. Bengt Ilon, a Swedish inventor, created the most efficient mecanum wheels in this research. The robot will operate better if it can reduce frictional forces [3]. Almost every electrical device has a microcontroller, which is a microprocessor [4]. PIC microcontrollers are processors that transfer signals to different components using RAM, built-in memory, and specialized input tools [5].The usage of unmanned ground vehicles (UGVs) in a variety of applications is growing, and developing control algorithms for these vehicles has presented researchers with a number of challenges. Intelligent self-driving cars, or UGVs, may carry out duties without a human operator on board [6]. These self-driving cars are mostly utilized for off-road navigation and, in particular, military tasks like border patrol and bomb detection that include uncomfortable, hazardous, or impossible situations. UGVs are operated by sensors that track characteristics that characterize the system's natural behavior and observe the surrounding environment, giving the system feedback signals via control algorithms [7]. UGVs may be categorized based on the kinds of controllers, their characteristics, and their structure. The components of a UGV are as follows: Sensors: UGVs are outfitted with sensors that enable them to keep an eye on their environment. Consequently, they provide controlled movements, even in very unforeseen environments like battlefields or fires. Control: The UGV's control system algorithms, which range from conventional control to more advanced techniques like adaptive control, robust control, and intelligent control, are largely responsible for determining its autonomy and intelligence. When using remotely controlled vehicles (ROVs) in military operations, communication is very important [8]. When people communicate with the majority of contemporary UGVs, they participate in the decision-making process throughout the vehicle's operation.Additionally, an accurate and durable communication connection—such as a radio link to fiber optics—is needed. Integration of systems: How a robotic system interacts is greatly influenced by the choice of system-level structure, configuration, sensors, and other components. Well-designed UGV systems will become adaptable and self-sufficient. Consequently, there will be more autonomy in the sector [9–10].

The commercial potential offered by this crucial unmanned systems marketplace are evaluated in the reference [11].

The report evaluated the many elements influencing global sales growth and looked at the top 12 national markets for unmanned ground vehicles (UGVs) by sales. According to this survey, governments throughout the globe spent a total of $702 million on UGVs in 2011. Given its wide range of uses in both the military and civilian sectors, this research highlights the significance of possessing such technology.

An electrical unmanned ground vehicle (EUGV) is a vehicle that can function while in touch with the ground most of the time without the requirement for human control. The car will often include navigation systems such a Global Positioning System (GPS) and electronic sensors to monitor the surroundings and identify the vehicle's direction and current angle. It will either make judgments about its behavior on its own or transmit the information to a human operator at a separate place, who will use teleportation to manage the vehicle.

An essential part of any EUGV is an effective, user-friendly Ground Control Station (GCS). The GCS collects all of the EUGV's status data and allows instructions to be sent in accordance with the designated missions in order to operate it. UGVs are often described as programmable, specially designed vehicles that can plan and carry out their mission duties in dynamic situations with little to no human interaction by employing sensors, measurements, and controls to collect and extract information from their surroundings [12].

Depending on the navigation system to be used, a variety of controllers are employed in such EUGVs, ranging from Inertial Navigation Systems (INS) to Global Navigation Systems (GPS), which overcome the majority of the drawbacks associated with using the traditional INS as a standalone system, such as inaccuracy. Higher precision GPS receivers may provide location data [12]. To make precise turns toward the target locations, precise UGV navigation needs the UGV heading readings from a GPS module or a digital compass. Because it is difficult to describe the vehicle/terrain interactions owing to ambiguity about the nature of the terrain, UGV navigation over uneven terrain is a complicated task [13–14]. To estimate the location of UGVs using various sensors, including stereo vision systems, laser range finders, and UGV odometers, a unique localization approach has been used [15].

MATERIALS AND METHODS

The mechanical, electrical, and control components of the EUGV that were chosen after performing the necessary theoretical calculations are taken into consideration in this study. UGV turning angles and radius between steering and wheels, with a clockwise CW, FR = 20˚ and FL = 18˚, where R is the turning radius for the forwarding wheels and r is the turning radius for the rear wheels, W is the distance between the forward and rear wheels, in our case 177.1 cm, and α is the turning angle, so R and r for the right wing will be 194 and 79.4 cm, respectively, and 236 and 155.7 for the left wing. We must determine the amount of power needed to totally stop the car in order to develop an effective braking system. Given that the UGV is driven by an electric drive train, it is crucial to determine whether or not the induction motor dynamic braking would be sufficient to bring the vehicle to a stop. These computations are crucial for making a decision. It helps us determine if the electric powertrain is sufficient or whether additional braking systems, such as hydraulic, electric, or assisted brakes, are required. With a UGV mass of 400 kg, a maximum velocity of 10 km/h, and a friction coefficient μ of 0.7, the calculations yielded a braking distance of 0.58 m, a barking time response of 0.4 s, and a 3.84 KW necessary power to stop the vehicle.

The kinematics of the redesigned UGV suspension system are fastened and pierced to act as adapters to mountain the absorber from both the head and the bottom. On both sides of the car, the two plates are riveted to the chassis. Gas absorbers and linear springs make up the competency components. In evaluating the system, we shall refer to the natural frequency and damping ratio. Given the simplicity of the suspension design, the power spectrum density formulae would result in complicated computations that we may not need.The intended UGV is provided with many sensors and actuators starting from Temperature and Humidity sensor, JSN-SR04T Ultrasonic, GPS, AC motor, Wireless video link, Xbee. Joystick and Pressure sensor beside the needed power supply. Lithium-Ion Battery GBSystem(GBS-LFP100Ah) has been chosen as a power system for this EUGV with the required features (240VDC, 100Ah, 40A).

Figure 5 below shows this type of battery that can give about two hours of endurance time for a weight of 450 Kg UGV and can function all peripherals installed on this UGV. Figure 2 shows the independent rear induction motors used in this UGV with each 4 KW (5.5 hp) has been calculated with torque 31.5 N.m and 1400 rpm. Figure 3 shows the high reduction worm Gear –Box with hollow shaft includes an integrated input shaft with a reduction ratio of 7.5:1, maximum power at the radial load of 3081N, output torque at gearbox of 184Nm, and output speed at gearbox of 187 rpm**.**

Figure 1. Lithium-Ion Battery



Figure 2. Induction Motor



Figure 3. Gear -Box

Starting with an Ultrasonic Proximity Sensor, which comprises of a transmitter and a receiver transducer to broadcast pulses, the majority of echoes are received after being slightly reflected off a barrier found in the way. Sensors for temperature, humidity, and pressure: Contrary to popular opinion, these sensors detect and transform original temperature, humidity, and pressure data throughout the EUGV into a corresponding electrical pretty signal that mainly flows to the microcontroller [16]. As a navigation technology, GPS primarily establishes the vehicle's direction and overall current position in a subtle manner. The XBee S3 Module, which is essentially a suite of very high-level communication protocols used to create pretty personal area networks built from small, low-power digital radios, effectively covers a range of 4 kilometers, proving that GPS is a navigation system that can accurately determine the heading and current location of the vehicle in a significant way. Video camera that captures real-time footage of the surroundings that EUGV passes through, sends it mostly via wireless TX to RX, and subtly shows it on a highly portable display. For all intents and purposes, Figure 4 below depicts the block diagram of those sensors connected to the Arduino Mega. It shows how the XBee S3 Module, which is a suite of fairly high-level communication protocols used to essentially create a personal area network built from small, low-power digital radios and covers a range of 4Km, demonstrates that GPS as a navigation system primarily determines the heading and fairly current location of the vehicle, which is quite significant.

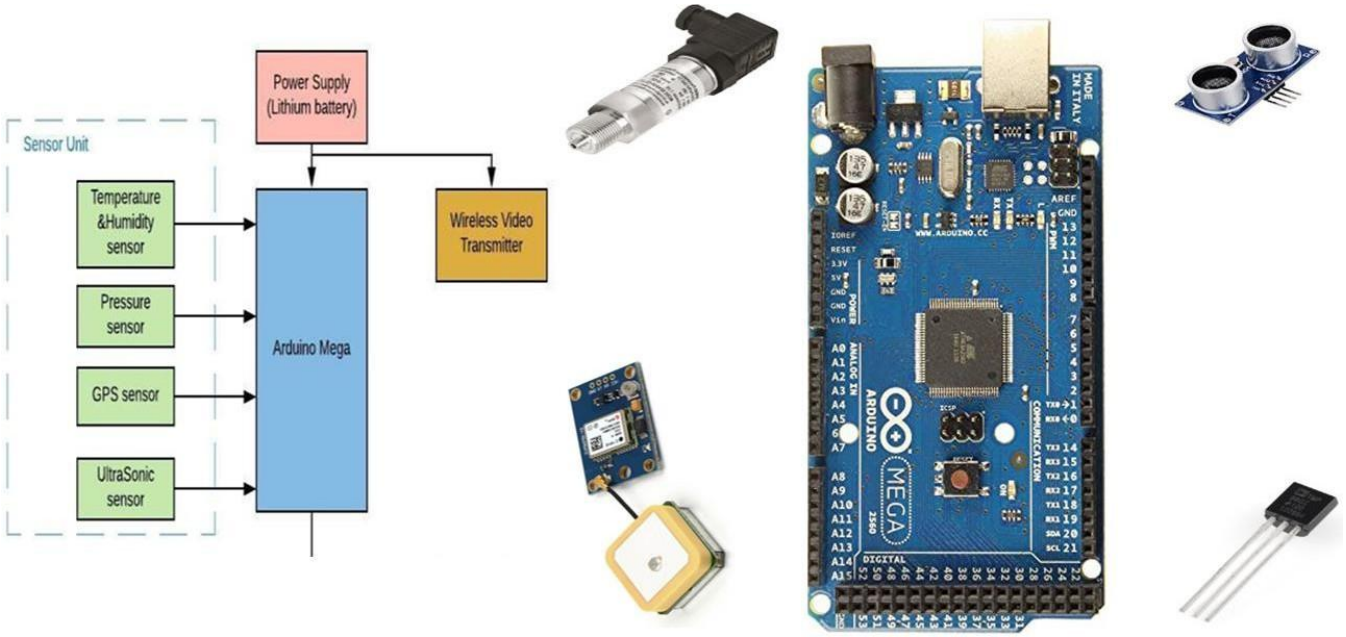


Figure 4. Sensors connected to Arduino Mega

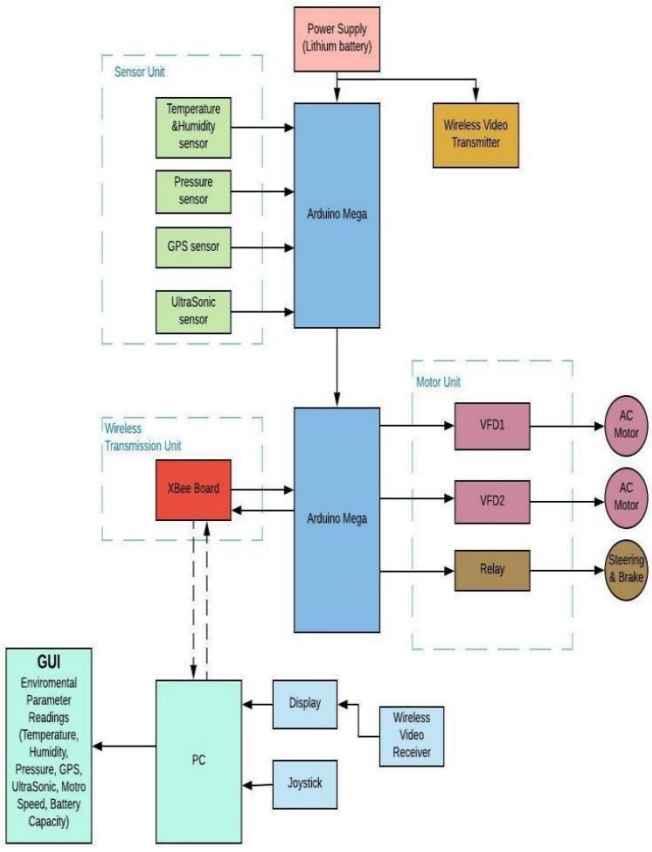


Figure 5. block diagram of all peripherals connected to EUGV

By altering the motor input frequency and voltage, a two variable-frequency drive (VFD) has basically been utilized to adjust AC motor speed and torque. As shown in Figure 5 below, it has been connected to a second Arduino Mega; particularly noteworthy is the connection of a wireless video receiver to a PC. As shown in Figure 6, an algorithm has been developed to display and manage the EUGV's navigation track.

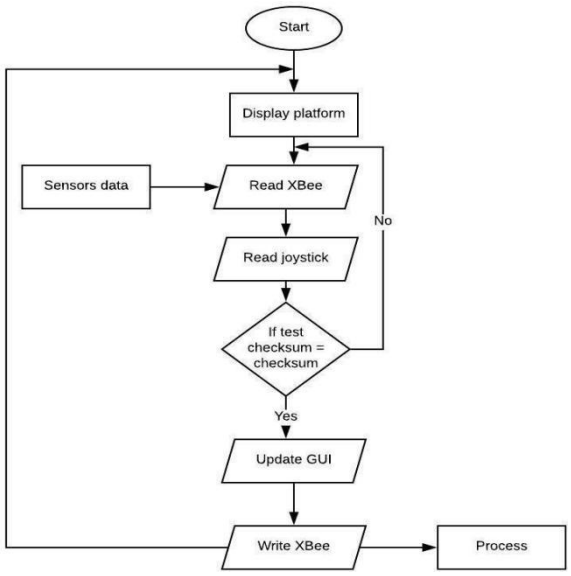


Figure 6. Ground station Algorithm

RESULTS

The stiffness sort of constant (K) and damping coefficient (C) are often required to create the formula that determines the systems' kind of natural frequency and damping ratio, relying on the following equations: in a subtle manner, in order to have a realistic testing procedure.

$$\zeta = C / 2 \times (K \times m)^{½} \quad (1)$$

$$\zeta = C / C^{o} \quad (2)$$

$$C^{o} = 2 \times K \times m/g \quad (3)$$

$$C = 2 \times m \times \omega_n \quad (4)$$

$$K = m \times \omega_n^2 \quad (5)$$

ζ: damping ratio, C: damping coefficient, C^o: critical damping coefficient, K: stiffness constant, m: mass, ωn: natural frequency, g: gravity.

Contrary to common perception, we conducted the load cell test on a Roehrig shock dyno that is specifically equipped with attachments for testing suspension springs in order to determine the two critical inputs from the preceding equation. Figures 7 and 8 show the results of the Roehrig shock dyno device test. Software tests accurately determine the stiffness ratio for the two tests as K1 = 48.02 N/mm and K2 = 46.98 N/mm for the front springs and K1 = 30.57 N/mm and K2 = 30.64 N/mm for the rear springs, which is very important.

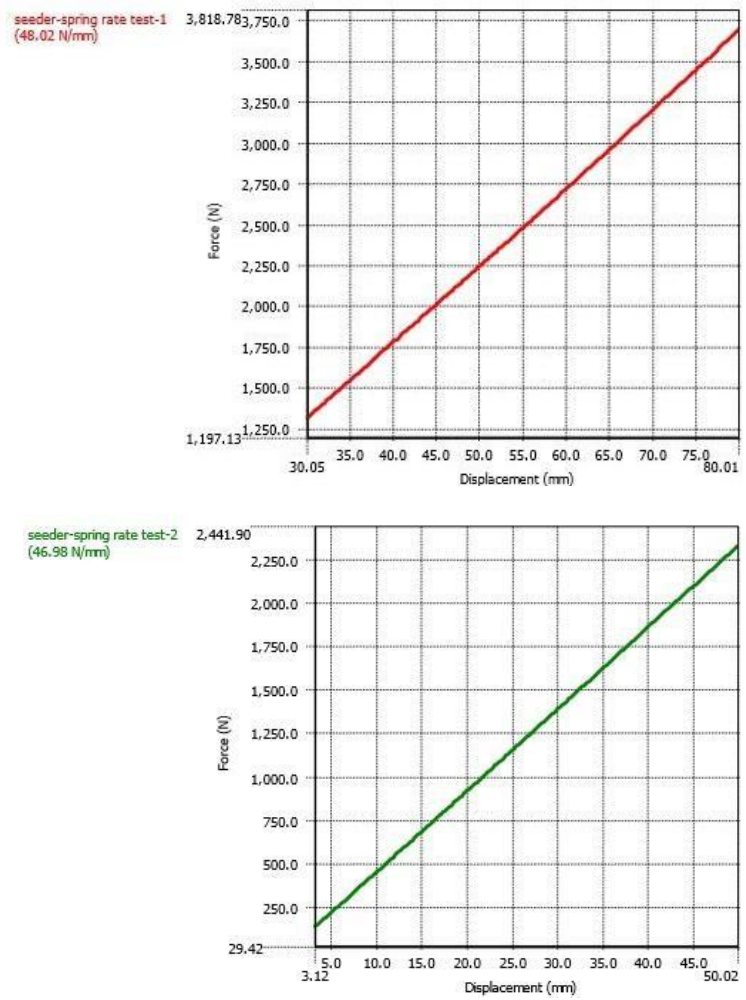


Figure 7. Forward spring rate test 1, 30mm,3.12mm preload, respectively

For the most part, the shock absorber test relies heavily on the connection between force in N and velocity in mm/s. It establishes the damper's ratio and damping properties (shock). In order to ensure accurate inspection, two types of tests were created, mainly for PVP; for the linear relationship to display the peak compression-rebound force with velocity and CVP; and for the continuous graph that essentially shows, bit by bit, what happens to the damper across rebounding and compression in two cycles each; very open cycle and specifically for all intents and purposes close cycle, or so they specifically thought, definitely contrary to popular belief. Figure 7 primarily depicts the CVP absorber test, specifically closed and actually opened cycles for compression and rebound, whereas Figure 10 shows the PVP absorber test, where the linear relationship is essentially definitely negative for a rebound and very definitely positive for compression, indicating that it determines the damping characteristics and ratio of the damper (shock). Two types of tests were created for accurate inspection: PVP; a linear relationship that shows the peak compression-rebound force with velocity and CVP; and a continuous graph that primarily shows bit by bit what happens to the damper across rebounding and compression in two cycles each; very open cycle and generally actually close cycle in a subtle way, generally contrary to popular belief.

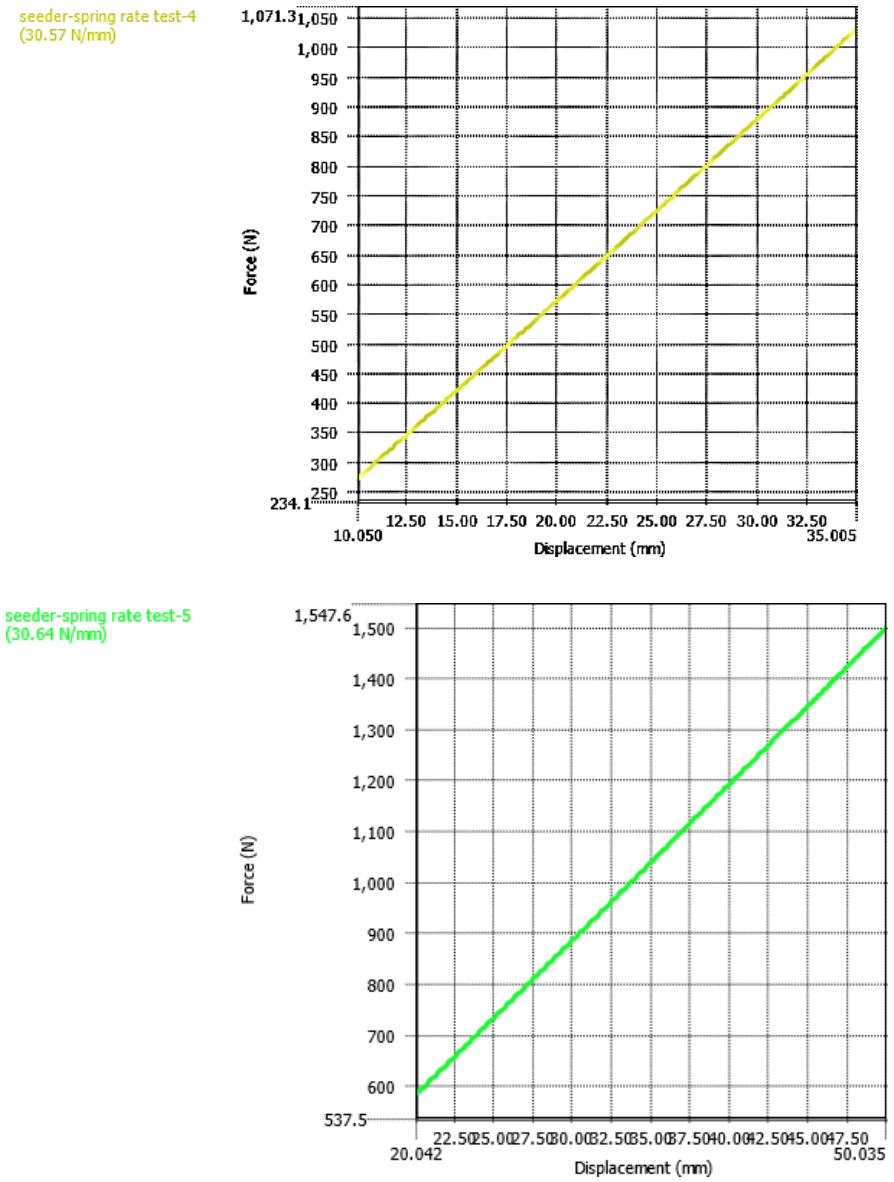


Figure 8. Rear wheels spring rate test 10mm preload and 25mm preload, respectively

GPS, AC motor, JSN-SR04T Ultrasonic, temperature and humidity sensor, Among the sensors and actuators in the planned UGV are Xbee and a wireless video link. A joystick and a pressure sensor are needed in addition to the necessary power source. The GBSystem (GBS-LFP100Ah) Lithium-Ion Battery was selected as the power system for this EUGV because it offers the required features (240VDC, 100Ah, 40A). A 450 kg UGV can run all of its fitted peripherals for around two hours on the batteries shown in Figure 1. The two independent rear induction motors used in this UGV, each rated at 4 kW (5.5 hp) and rotating at 1400 pm, are shown in Figure 2. The high reduction worm Gear-Box with hollow shaft shown in Figure 3 features an integrated input shaft with a reduction ratio of 7.5:1, an output torque of 184Nm, an output speed of 187 rpm, and a maximum power at the radial load of 3081N.

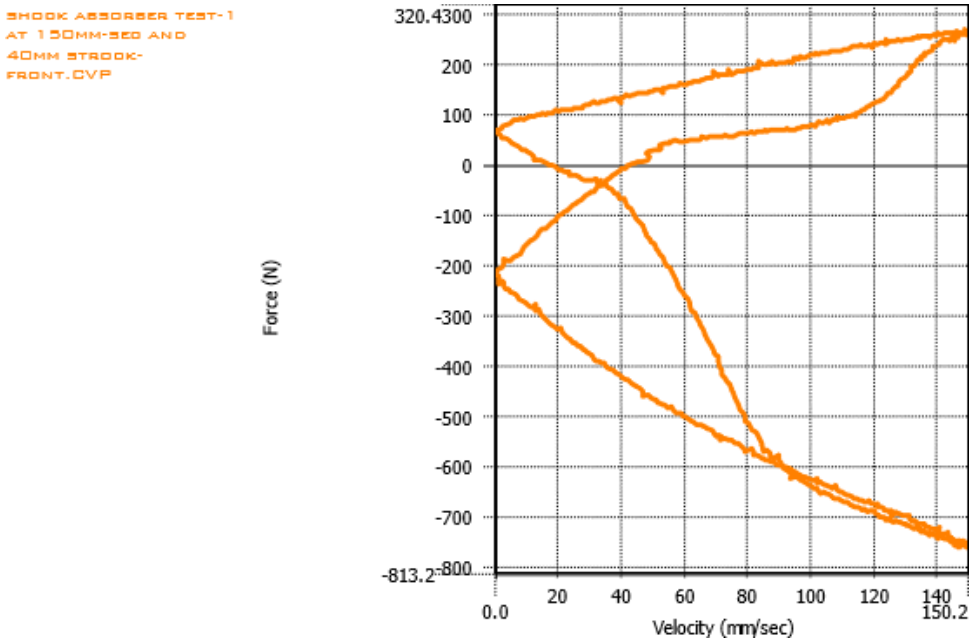


Figure 9. CVP absorber test closed and opened cycles for compression and rebound

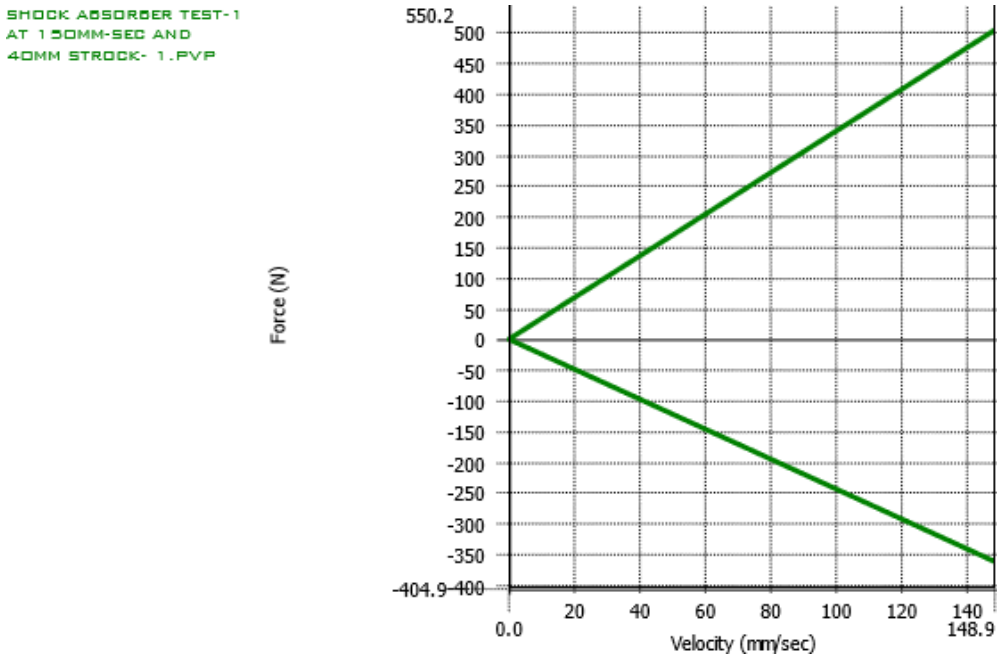


Figure 10. PVP absorber test, linear relationship in positive for compression and unfavorable for a rebound

DISCUSSION CONCLUSION

An unmanned vehicle operates without a human occupant. Either an automated setup or a remote control system might be used to drive the vehicle. The Association for Unmanned Vehicle Systems International claims that unmanned vehicles are extensively used in the commercial, civic, and military domains. An unmanned land-based vehicle that carries out dirty,

risky, or hazardous operations is known as an unmanned ground vehicle.These self-driving cars are mostly utilized for off-road navigation and, in particular, military tasks like border patrol and bomb detection that include uncomfortable, hazardous, or impossible situations. UGVs are operated by sensors that track features that characterize the system's natural behavior and observe the surrounding environment, giving the system feedback signals via control algorithms. The majority of contemporary UGVs communicate with humans, who participate in the decision-making cycle throughout the vehicle's operation. A vehicle that runs while in touch with the ground without requiring human control is known as an electrical unmanned ground vehicle.

Typically, the car will include navigation systems like a GPS and electronic sensors to track its direction and angle as well as monitor its surroundings. It will either decide how to behave on its own or transmit the information to a human operator who is in a different place and will use teleportation to manage the vehicle. Depending on the navigation system to be utilized, a variety of controller types are used in such EUGVs, ranging from Inertial Navigation Systems to Global Navigation Systems, which solve the majority of the drawbacks associated with utilizing the traditional INS as a standalone system, such as inaccuracy. To make precise turns toward the target locations, precise UGV navigation needs the UGV heading readings from a GPS module or a digital compass. Because it is difficult to predict the vehicle/terrain interactions owing to ambiguity about the terrain's characteristics, UGV navigation over uneven terrain is a complicated task.

The location of the UGV has been estimated using a unique localization approach using several sensors, including the UGV odometer, laser range finder, and stereo vision system. It helps us determine if the electric powertrain is sufficient or whether additional braking systems, such as hydraulic, electric, or assisted brakes, are required. With a UGV mass of 400 kg, a maximum velocity of 10 km/h, and a friction coefficient μ of 0.7, the calculations yielded a braking distance of 0.58 m, a barking time response of 0.4 s, and a 3.84KW necessary power to stop the vehicle. With the necessary characteristics, the Lithium-Ion Battery GBSystem has been selected as the power system for this EUGV. The primary function of GPS as a navigation system is to discreetly identify the vehicle's direction and present position. The XBee S3 Module is primarily a set of very high-level communication protocols used to create fairly personal area networks constructed from small, low-power digital radios. It essentially covers a range of 4 kilometers, proving that GPS is a navigation system that can accurately determine the heading and current location of the vehicle in a significant way. The GBSystem Lithium-Ion Battery was selected as the EUGV's power supply because it offers the necessary features.

CONCLUSION

An E-UGV controller equipped with a situational awareness system is designed to move on the ground either autonomously, without the need for a human driver, or by remote manual control. Numerous sensors are available for use in surveillance and reconnaissance operations. For instance, they provide first responders with up-to-date information on the situation at the operation site. Designing and building a (EUGV) controller with a special function was the aim of this project. Using rechargeable batteries with a two-hour endurance time, the EUGV is a fully electric vehicle with a GCS that controls its mission by gathering data from many sensors and a 4-kilometer video connection. There are two forms of control available: semi-automated control and manual control. The study's description of an obstacle detection and avoidance sensing system is most important. This sort of controller's main objective is to use Ground Control Stations (GCS) to collect intelligence, surveillance, and reconnaissance (ISR) capabilities to reduce human risk in difficult terrain.

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