Received: 16 February 2023 | Revised: 5 May 2023 | Accepted: 11 May 2023

DOI: 10.1002/eng2.12703

RESEARCH ARTICLE

Engineering Reports Open Access WILEY

The proof of concept of uninterrupted push-pull electromagnetic propulsion and energy conversion systems for drones and planet landers

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Funding information

Aeronautics Research & Development Board, Grant/Award Number: ARDB/GIA/2022/000009

Abstract

Although numerous models of aerial-robots/drones and planet landers have been demonstrated to fly autonomously in natural and manmade environments for far-reaching scientific and technological change to help humankind, no drone flowed yet with a push-pull dual-head electromagnetic propulsion (EMP) system ensuring unrestricted flight endurance. The precept of EMP is eminent as it hastens an object using a flowing electrical current, either to charge a field or opposing a magnetic field for locomotive use. Here we present a proof of concept to demonstrate the capability of a newly invented variable speed propulsion and energy conversion system for uninterruptedly generating the reciprocating motion of a magnetic piston by a solar battery-driven polarity changer timing circuit together with a laser-based timing circuit for redundancy. The reciprocating crusade of the magnetic piston could be successfully converted into rotary motion to generate continuous power for various multidisciplinary applications on Earth and the other planets effectively in lieu of long-lasting rechargeable batteries. The proposed concept can also be used for devising various systems and subsystems from underwater to outer space by using light weight supermalloy, which ensures high magnetic fluxes with relatively low current. Lucrative applications include nanomaterial-enabled locomotive applications. Aerial robots regulated with the EMP system could be used for fostering pharmaceutical florae in the international space station for drug design to negate the recently discovered phenomenon of Sanal flow choking in cardiovascular system at gravity and/or microgravity conditions. This concept is originated from mind and aimed for lucrative product developments of yocto to yotta scale energy systems and beyond by discovering new magnetic materials through the fourth industrial revolution. Herein, a proof of the concept of an unrestricted solar-battery driven push-pull electromagnetic propulsion and energy conversion device by use of light weight high power magnetic materials is presented.

KEYWORDS

Energy conversion system, drone, electromagnetic propulsion, planet lander

1 | INTRODUCTION

Aerial robots, also known as drones, are considered to be one of the most promising technologies emerging from the fourth industrial revolution.[1,2] Many countries are now using drones to help combat the spread of COVID-19. Drones are being utilized for various purposes, including surveillance and enforcement of lockdowns, public broadcasting, monitoring of body temperatures, delivering food and medicine to people under quarantine, and spraying disinfectants. Apart from COVID-19 response, drones have potential applications[2–10] in lucrative surveying and gravity mapping,[6] agriculture,[2] defense,[10] and soft landing of planet landers.[9]

Research and development efforts are underway to improve the capabilities of drones and explore new areas of application. For instance, researchers are working on improving drone autonomy and developing swarms of drones for coordinated missions. In addition, there is growing interest in using drones for delivery services, such as delivering packages and groceries to customers' doorsteps. Furthermore, the use of drones in the entertainment industry, such as filming and capturing aerial footage for movies and events, is also gaining traction. As technology advances and regulations become more favorable, the potential applications for drones are expected to continue to expand.

Although many types of drones and aerial robots have demonstrated the ability to fly autonomously in various environments using different energy conversion systems, no drone has yet used a push-pull dual-head electromagnetic propulsion (EMP) system for unrestricted flight endurance.[1–8] EMP is a well-known principle that accelerates an object using an electrical current, either by charging a field or opposing a magnetic field for locomotive use in various industrial applications. The push-pull EMP is a technique that involves the use of two electromagnets, an electrical current, and attraction and repulsion magnetic fields to accelerate an object. It is well known that by passing an electric current through a conductor in a magnetic field, a Lorentz force is generated that pushes the conductor perpendicularly to the magnetic field and conductor. The simultaneously generating attractive and repulsive forces by two separate electromagnets can be harnessed for propulsion in a designed system. Note that EMP does not use the electrical energy to produce rotational energy for motion. In this context, a proof of concept has been developed to showcase the capability of a newly invented variable speed push-pull propulsion and energy conversion device. This device generates the back-and-forth motion of a magnetic piston using a solar battery-powered polarity changer timing circuit (PCTC), along with an laser-based timing circuit (LBTC) for redundancy. The mean speed of the magnetic piston is a function of stroke and rotor speed. It can be altered by a feedback-controlled timing circuit capable of changing the polarity of both magnetic heads to achieve the desirable stroke and rotor speed. Changing the magnetic pole strength onboard/off board is another option for achieving the intended rotor speed. The timing circuit can be operated with a rechargeable solar cell with low power consumption. Note that the solar panel with one square centimeter can provide approximately 0.03 W.

The proposed EMP system is unique because it incorporates feedback control of the back-and-forth motion of the magnetic piston, along with a connecting-rod and crankshaft. This enables the system to continuously acquire the desired speed of each rotor of a quadcopter/drone for earth-based missions[5,6] and other planetary explorations, with a predetermined trajectory.[4] This means that the system can be used in a variety of applications where precise control of the drone's movement and speed is required. Note that the linear movement of the piston can also be converted to a rotating movement by a swashplate (a device that converts input via flight controls into motion of the rotor blades) or another suitable mechanism, which depends on the type of aerial robot and its lucrative applications. The dual-head EMP system presented herein is a promising device for uninterrupted power generation and storage of energy for various multidisciplinary applications. The dual-head EMP system integrated with drones is more useful during natural calamities due to its amazing flight endurance. Note that the existing drones could fly autonomously in natural and man-made environments only with restricted flight endurance.[2]

Currently, the development of unrestricted autonomous drones for Earth and other planetary explorations are highly demanding worldwide.[1–29] This is true for the design of industrial robots facilitated with push-pull EMP system.[9,18,20,27,28]

The precise control offered by the push-pull EMP system is essential in the design of space robots, including quadcopters and drones, for various applications such as space debris mitigation in space stations, using tools such as space brooms or otherwise.[18] Additionally, the system is useful for deep space propulsion probes and planet landers, enabling soft landings on extraterrestrial bodies,[9,19–21] fostering pharmaceutical florae in space labs.[27–29] The ability to continuously adjust the drone's speed and trajectory is critical in these applications, where any deviation from the planned course could result in mission failure. The EMP system's precise control is essential in the design of energy conversion and harvesting devices for space and defense applications.[22–26] These applications require the continuous monitoring and adjustment of the drone's movement and speed to ensure optimal performance and efficiency. With the EMP system's feedback control, the drone can be used in a range of applications that require precise control and monitoring, making it a valuable tool in various fields. Drones have been operated mainly in airborne platforms with a comparatively high overall mass and less flight durability.[2] Lithium-ion batteries used in drones suffer severe power loss at very low temperatures (less than 0°C), limiting their use with environmental temperature restrictions on the Earth and other planets.[30–33]

The beginning of the art of EMP does not fall on anyone, but many researchers have discovered numerous industrial applications of EMP in the multidisciplinary domain for further investigations.[1–6,19–21] Despite numerous inventions related to electromagnetic propulsion and energy conversion systems reported in literature,[34–39] no agency or individual has yet developed an uninterrupted propulsion and energy conversion system like the proposed push-pull dual-head electromagnetic propulsion system (EPS). This system is powered by a solar-battery powered PCTC and LBTC and can operate continuously during day and night for various industrial applications in different sizes and scales. The fact is that the push-pull dual-head EMP system can produce uninterrupted reciprocating motion of a piston using a solar-powered timing circuit. It is a basis for the energy conversion system for various applications from underwater to the outer space range. Note that chemical propulsion systems are energy limited and electrical propulsion systems are power limited. Therefore, drones with dual-head EMP systems will be highly demanding for future industrial applications.

EMP system-integrated drones have numerous applications not only in the aerospace industry but also in the near-earth atmosphere reconnaissance, especially during natural calamities and the failure of other communication network systems. The push-pull EMP system is perfectly appropriate for various industrial appliances, planetary exploration system designs and planet landers for soft landings.[19–21] Such aerial robots are facilitated with proper governance of attitude and altitude with multiple rotors (using quadcopter (Figure 1) or contrarotating propellers (Figure 2)).[20,21] It can be used for vertical takeoff from any harsh terrain,[20] where the natural or man-made atmosphere persists. Bluman et al.[39] reported the Marsbees aerial vehicle concept for Mars exploration. We determine herein that the EMP system integrated with the quadcopter/drone is the eloquent objective for the design and development of energy conversion systems for various long-range aerospace and environmental science applications.[38] Compared to the existing piston engines,[36,37] our proposed dual-head EMP is unique for the unrestricted flight endurance of quadcopters/drones (aerial robots).

A literature review reveals that several types of miniature new generation devices have been proposed by various studies for nanomaterial-enabled locomotive applications. The push-pull EMP system has great potential in the design of energy harvesters, biomimetic robots,[38] aerospace engineering systems, defense mechanisms,[40–43] and other applications.[44] The precise control of EMP systems makes them suitable for the design of biomimetic robots that can mimic the locomotion and movement patterns of animals and insects. The design of nanotechnology-enabled flying vehicles with

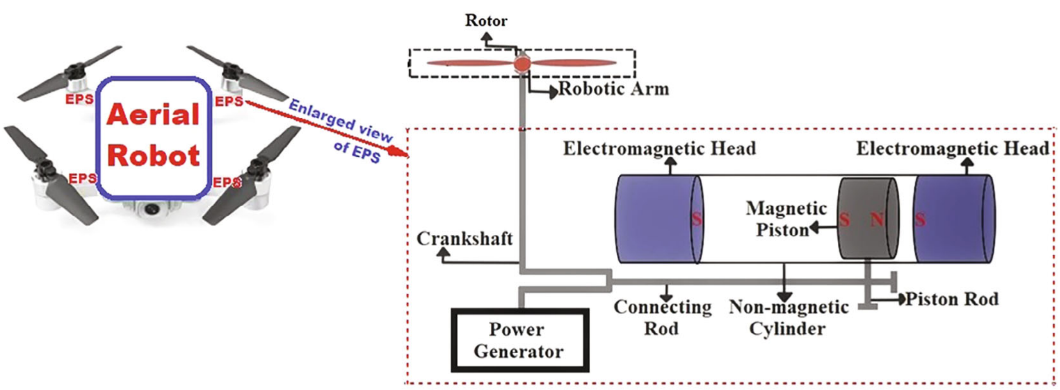

FIGURE 1 The physical model of a push-pull electromagnetic propulsion system (EPS) integrated with an aerial robot.[20]

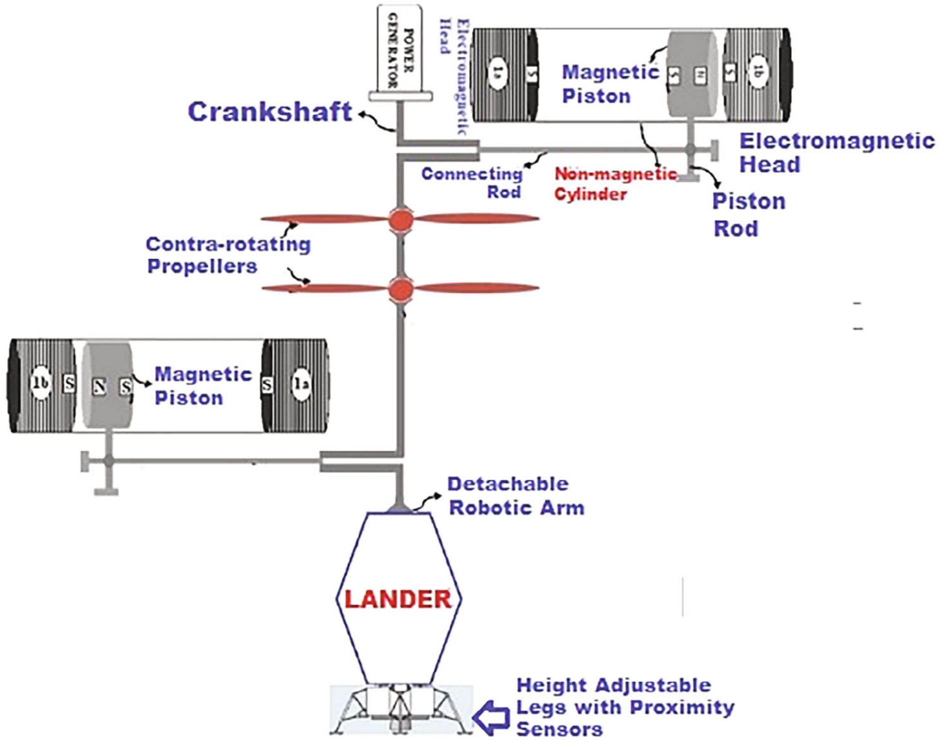

FIGURE 2 The design of a planet lander with push-pull electromagnetic propulsion systems for the soft landing with contra-rotating propellers. (see the online material: Movie S1–Planet lander animation with a single rotor: https://youtu.be/nb6dWPGJPGI)

nanoscale thrusters[44] in the outer space and at the corridor of various planets is of topical interest. Note that nanoscale chemical thrusters can be replaced with nanoscale EMP systems in the future. The main focus of this article is to showcase the newly developed push-pull dual-head EMP system, which is capable of generating the to and fro motion of a magnetic-piston with high momentum continuously using a solar battery-driven PCTC and an LBTC. The authors believe that this push-pull EMP system can be utilized in designing and developing various dual-head EMP systems of different sizes and scales for future technological applications in different fields, while also reducing the electrical consumption of an electromagnet.

When a magnetic piston moves back and forth due to changes in polarity of the two electromagnets, there will be some energy loss due to factors such as friction and electromagnetic induction. The exact amount of energy loss will depend on various factors, including the design of the system, the materials used, and the speed and frequency of the piston's movement. To minimize energy loss, the designers can optimize the design and materials of the system, as well as the timing and duration of the polarity changes in the electromagnets. Additionally, energy harvesting techniques can be employed to capture and reuse some of the energy lost during the piston's movement. There are several types of losses that can occur in a magnetic field, namely, hysteresis losses, eddy current losses, leakage losses, and stray losses. Overall, these losses can reduce the efficiency of magnetic devices and systems, and designers must take them into account when developing magnetic systems for various applications. A literature review reveals that the length of time it takes for a magnet to lose its energy, or magnetic strength, depends on several factors such as the type of magnet, its size, and the conditions in which it is stored or used. In general, permanent magnets made of materials like neodymium or samarium-cobalt can retain their magnetization for a very long time, sometimes up to several decades or even centuries.[45] However, exposure to high temperatures, strong magnetic fields, or mechanical shock can cause demagnetization and lead to a gradual loss of magnetic strength over time. Additionally, certain factors such as corrosion, humidity, and radiation can also affect the magnetic properties of a magnet and cause it to degrade more quickly. In summary, the energy loss of a moving magnet is related to thermodynamics through the conversion of energy into heat and the increase in entropy of the system, as described by the laws of thermodynamics. Cooling the system can potentially reduce the energy loss, but it cannot completely revert the energy loss due to the fundamental principles of thermodynamics.

It is well-known that there are many ways to minimize the electrical consumption of an electromagnet. For instance, use of supermalloy,[46] one of the best-known options. Supermalloy is a type of magnetic alloy that is composed of nickel, iron, and molybdenum. It has a very high magnetic permeability and a low coercivity, which makes it useful for applications where strong magnetic fields are required. Supermalloy is often used in the construction of sensitive scientific instruments, such as magnetometers, as well as in electromagnetic shielding applications. The composition of supermalloy is 75% nickel, 20% iron, and 5% molybdenum. This alloy has a resistivity of $0.6\,\Omega\cdot\text{mm}^2/\text{m}$ (or $6.0\times10^{-7}\,\Omega\cdot\text{m}$), which means it has relatively low electrical resistance. Additionally, it has an extremely high relative magnetic permeability of approximately $800{,}000\,\text{N/A}^2$, which means it is highly responsive to magnetic fields. Finally, it has a low coercivity, which means it can be easily magnetized and demagnetized. This can largely intensify the magnetic field produced by a coil. It reveals that we can use very low current to achieve high magnetic fluxes and an augmented efficiency of any system operating with dual-head electromagnetic (DHEM) device.[47,48] This concept is originated from mind and aimed for lucrative product developments of yocto to yotta scale robots and beyond for marketing through the fourth industrial revolution.

2 | MATHEMATICAL MODEL

The push-pull EPS presented herein is an invention[47,49] as no space exploration device has a dual-head EPS integrated with a variable rotor speed quadcopter/drone rotor. EPS allows us to perceive the unknown planetary environment, particularly the fluid dynamics effects. Figure 3A depicts the classical model of the EPS with two electromagnets (EMs) for continuously obtaining the to and fro motion of the magnetic piston invoking the feedback control PCTC for various applications. Figure 3B depicts the general outline of the EPS with the pin location (P) of the piston, crank pin position (L_c) and crank center (C) for demonstrating the proof of the concept with a case study. Figure 4 shows the in-house experimental and theoretical[50] estimations of the force between two magnets.

The continuous strikes of the magnetic piston at both EMs using the feedback controlled PCTC enable the quadcopter/drone to spin its rotor(s) at the desired speed to complete its mission. This system is more beneficial for planet landers while touching down on the known or undiscovered planet surface due to gravity force or otherwise. The rotor speed could be altered according to the local density of the planet, which is determined onboard using basic physics and aerodynamics principle.

The governing fundamental equation of the movement of the magnetic piston shown in Figure 3A is

$$m_p \frac{d^2 x_p}{dt^2} = \frac{\mu q_1 q_2}{4\pi x_p^2} + \frac{\mu q_2 q_3}{4\pi\left(\delta + R - L - x_p\right)^2}. \tag{1}$$

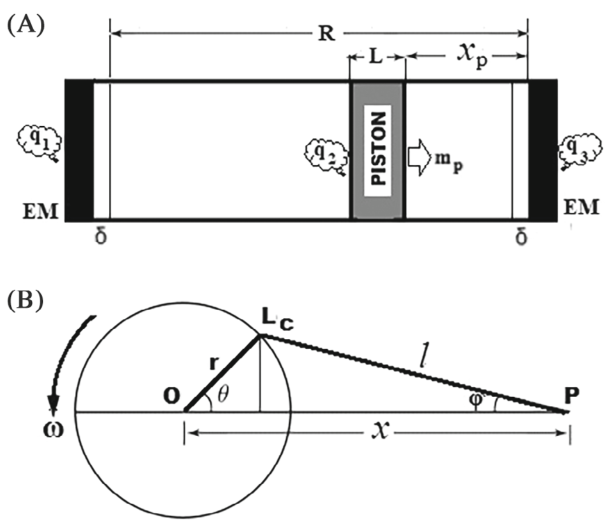

FIGURE 3 (A) An idealized physical model of a push-pull EPS for drones[9] and (B) the general outline of the EPS system with a crank pin[9]

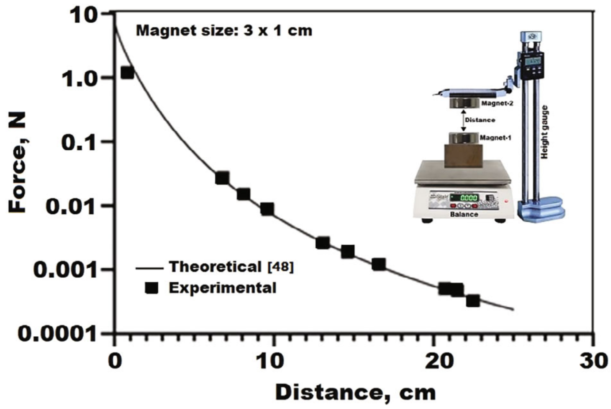

FIGURE 4 Experimental and the theoretical estimation of force between two magnets. The inset shows the experimental setup.

Herein, the magnetic pole strengths are taken as identical ($q_1 = q_2 = q_3 = q$) and Equation (1) becomes

$$\frac{d^2x_p}{dt^2} = P\left[\frac{1}{x_p^2} + \frac{1}{\left(\delta + R - L - x_p\right)^2}\right]. \tag{2}$$

The EPS system constant, P is obtained as

$$P = \frac{\mu q^2}{4\,\pi\, m_p}, \tag{3}$$

where μ is the permeability and m_p is the mass of the magnetic piston.

From Figure 3B the angular velocity of the crankshaft (ω) of the EPS is obtained as

$$\omega = -\frac{dx_p/dt}{\left(\sin\theta + \frac{\sin 2\theta}{2\sqrt{\left(\frac{l}{r}\right)^2 - \sin^2\theta}}\right) r}. \tag{4}$$

The acceleration of the magnetic piston is obtained as

$$\frac{dv}{dt} = -r\omega^2\left[\cos\theta + \frac{(l/r)^2\cos 2\theta + \sin^4\theta}{\left((l/r)^2 - \sin^2\theta\right)^{3/2}}\right], \tag{5}$$

where v is the velocity of the magnetic piston, which is taken as dx_p/dt, t is the time, r is the crank radius, θ is the crank angle from the top dead center, l is the rod length, and x_p is the axial position of the magnetic piston. The lander (see Figure 2) thrust can be estimated from the traditional lift/force equations.[51]

2.1 | Proof of concept

The main purpose of developing a proof of the concept is to demonstrate the functionality and to verify and validate the technical feasibility of a theory that can be achieved in development. In this article, we have presented proof of the concept of an unrestricted dual-head electromagnetic propulsion and energy conversion system governed by a polarity changing the timing circuit through laboratory static tests. Figure 1 depicts the physical model of a dual-head EPS integrated with a quadcopter/drone rotor (aerial robot). Figure 2 presents the conceptual design of the planet lander with the EMP system integrated with contrarotating propellers.[20] It is facilitated with height adjustable legs with proximity sensors for stable and soft landings (please see the supplementary material demonstrating the simultaneous vertical dropping of two identical landers (one EPS in the ON position and another OFF) for atmospheric density study – Online material <https://youtu.be/nb6dWPGJPGI>).

The counter-rotating propeller is linked to the Lander with the help of a robotic arm, which could be disconnected after soft touchdown for ensuing space-mission trials. To prohibit streamtube flow choking[29,52] and shock wave generation at the blade tip causing structural problems, the maximum recommended propeller speed in an adiabatic environment is limited to 693 km/h and that of the diabatic environment is 540 km/h with air as the working fluid. Having known the safe limit of the propeller speed, aerodynamic design optimization can be performed within the given envelope for aerial robots and planet landers through conventional methods.[51] Payload capability can be improved by selecting lightweight high-power magnets and miniature solar/lunar energy powered batteries.[53] The EMP system is capable of continuously producing rotor rotation of the drone through the reciprocating movement of the magnetic piston in the cylinder. The proposed system is designed in such a way that the magnetic piston is not in direct contact with the cylinder. We have provided sufficient clearance between the magnetic piston and the cylinder because there is no fluid or combustion product to leak through the clearance like traditional reciprocating chemical fuel engines. Safe clearance can be achieved through different techniques according to the system, namely, the magnetic levitation and/or piston rod—crank shaft mechanism and by invoking the touch-me-not magnetic-piston and piston rod mechanism. However, in the event of any contact between two surfaces (piston rod/cylinder or magnetic piston/cylinder) we can invoke various tribology solutions for frictionless rubbing, namely, through material selection, and lubricants. Please note that graphene (GR) nanoparticles have excellent lubrication performance. Briefly, in the future, tribology solutions can be invoked based on the system design, its endurance, and applications in yocto to yotta scale robots and beyond.

Figures 5–7 depict the overview of the laboratory static test setup of dual-head EMP and the energy conversion system. The EMP system is governed by the feedback controlled PCTC/LBTC. It is operating with solar/lunar energy powered batteries.[53] The PCTC/LBTC is used to vary the polarity of the magnets with linear or nonlinear time steps to continuously obtain mission-specific reciprocating movement. The feedback-controlled timing circuit is useful for obtaining the desirable rotor speed for achieving the necessary lift force in variable planet environments for hovering and/or the soft landing of aerial robots. We have demonstrated the to-and-fro motion of the magnetic-piston movement of the EMP system in the ground test using PCTC and LBTC (see Figures 5 and 6). The cylinder heads can be magnetized using a direct current source generated from lunar/solar energy or a rechargeable solar battery onboard. This allows for multidisciplinary applications and durability.

At the off-board, the EMP system was governed by the timing circuit and/or the variable-power electromagnet as the case may be. Our invention is the first generation of the push-pull dual-head EMP system. The proposed design is totally free from the ground support network system and the model is unique. The fact is that we could halt and govern the to-and-fro motion of the magnetic-piston a priori and/or a posteriori by invoking the PCTC/LBTC. Note that the reciprocating movement can also be altered by varying the magnetic pole strength (q) to achieve the trajectory prerequisite. It can be done onboard/off-board according to the type of industrial robot governed by the EMP system. The series of frames illustrates (see Figure 8) the continuous back-and-forth motion of the magnetic piston caused by the alternating polarity of the two electromagnets (corresponding to Figure 5C).

Figure 9 depicts the circuit diagram of LBTC. Dual-head EM were placed at both ends of the nonmagnetic cylinder, which was facilitated with a magnetic piston, PCTC/LBTC systems, and a battery. A feedback controlled PCTC/LBTC is aided in the EMP system for speed regulation. According to Figure 9, the design circuit for the polarity change of the LBTC encompasses a light-dependent resistor (LDR) and laser light. A switch mechanism is facilitated essentially to flip the circuit to change the polarity, while the piston rod obstructs the beam of laser light during the restricted movement between the laser light and the LDR (Figure 9 also see the laboratory test video in the supplementary material as Movies S3 and S4). Our model is an invention, as no space exploration device has a dual-head EMP system integrated with a variable rotor speed quadcopter/drone rotor. It allows us to perceive the unknown planetary environment, particularly the fluid dynamics and gravity effects.

The continuous strikes of the magnetic piston at both electromagnets using the feedback controlled PCTC/LBTC enable the quadcopter/drone to spin its rotor(s) at the desired speed to complete its mission. This system is more beneficial for planet landers while touching down on the known or undiscovered planet surface due to gravity force or otherwise. The rotor speed could be altered according to the local density of the planet. It is determined onboard using basic physics and aerodynamics principles.

The lander thrust can be estimated from the traditional lift/force equations.[50] The article utilizes the blade element momentum theory to investigate the soft landing of a planet lander, and uses established solution methods for theoretical

(A)

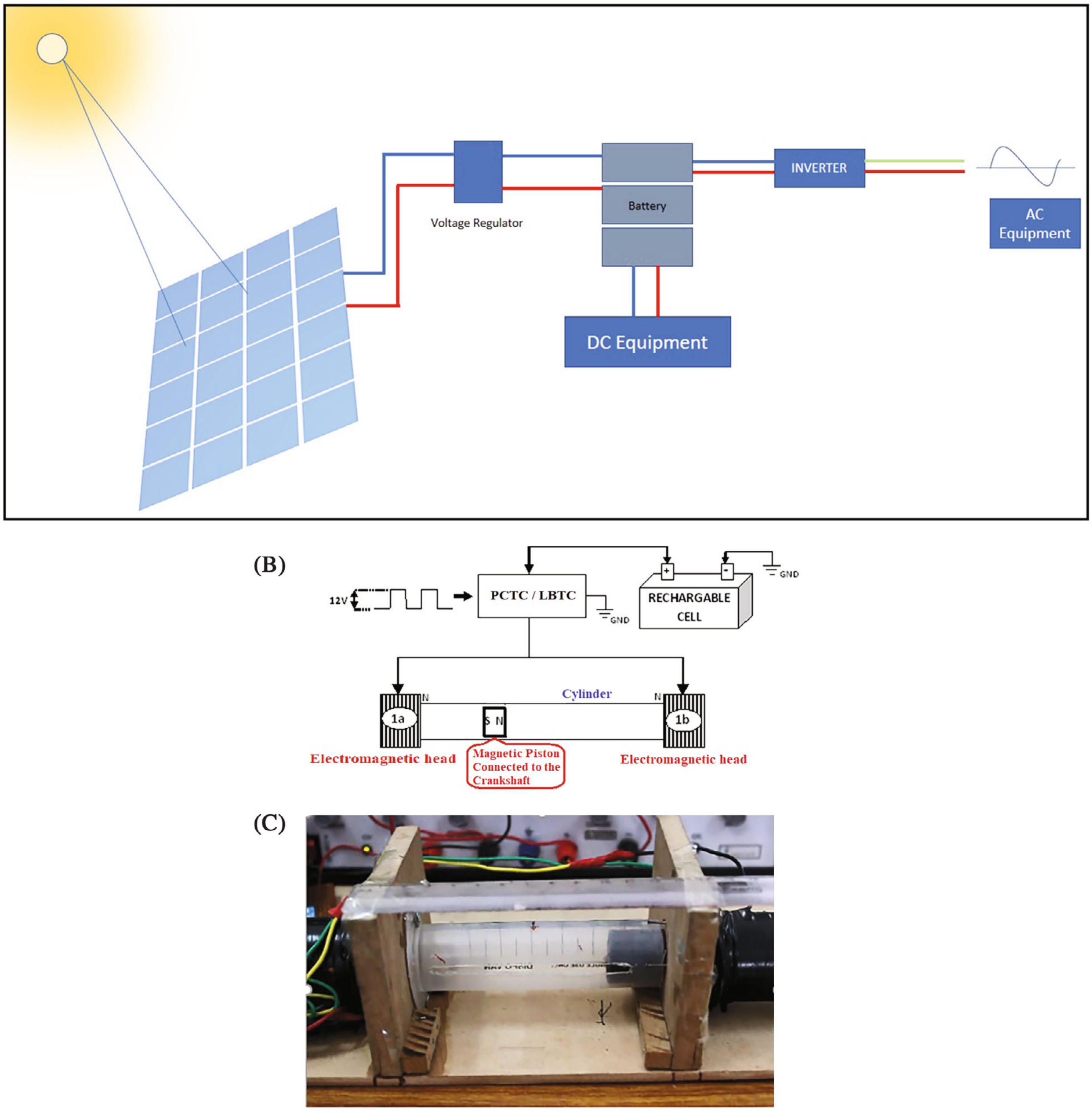

FIGURE 5 (A) Solar energy conversion system, (B) ground test layout of push-pull electromagnetic propulsion system (EPS), and (C) the push-pull EPS test setup with the PCTC (see Movie S2: Proof of concept of an unrestricted dual-head EPS: https://youtu.be/qWH5E_W0XeE)

predictions. To demonstrate this concept, a quadcopter/drone planet lander was controlled by the EMP system and simulations of the dropping characteristics were conducted using MATLAB/Simulink along with mixed reality simulation (MRS). The code has been validated with a real-time experiment.[21] MRS is the amalgamation of the virtual part along with the real part.

The initial conditions for the simulation of the lander drop were set with X = 0, Y = 0, Z = 55 km, which corresponds to a dropping height of 55 km above the surface of the Venus planet. Additionally, all desired commands, such as altitude, roll, pitch, and yaw, were set to zero. The atmospheric properties of Venus are taken from the open literature.[54]

The lander was successfully landed in a vertical position on the surface of Venus using the altitude and attitude controller, which can be seen in Figures 10 and 11. The X and Y positions were recorded, and the roll, pitch, and yaw angles were determined to be almost zero, meeting the mission objective. This was achieved using an EPS-regulated lander. The simulation results showed that as the lander descended towards Venus, its landing velocity decreased rapidly once

FIGURE 6 The static test of a dual-head electromagnetic (DHEM) propulsion system on a testbed with LBTC (Laser in ON)[20] (see Movie S3 Laboratory qualification test of dual-head EPS: https://youtu.be/itNQowXaCPM)

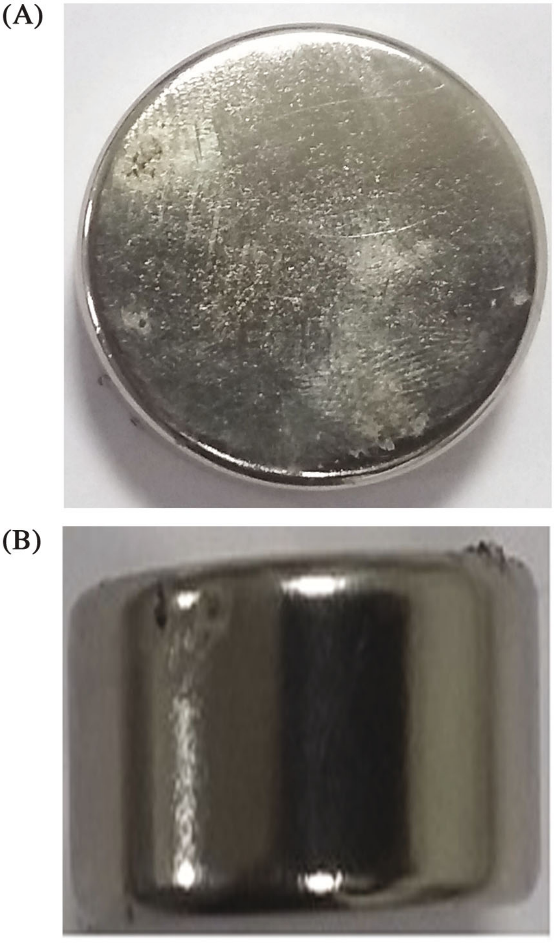

FIGURE 7 (A) The photographic top view of the magnet and (B) the photographic side view of the magnet

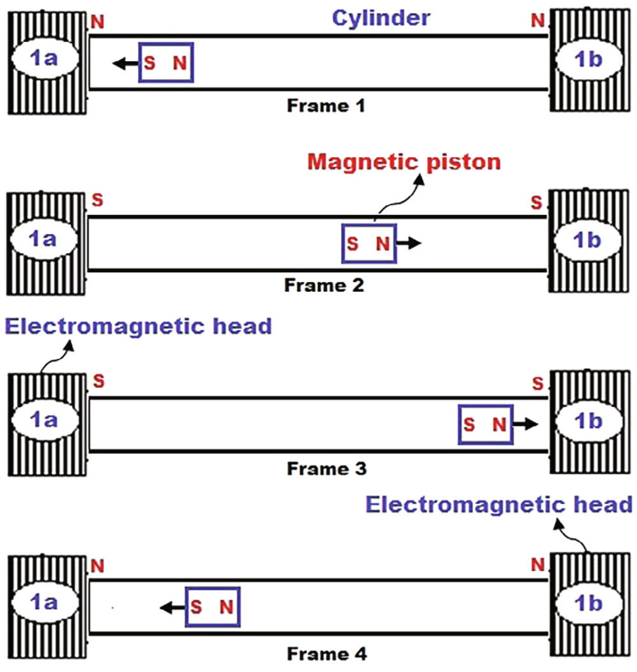

FIGURE 8 The series of frames illustrates the continuous back-and-forth motion of the magnetic piston caused by the alternating polarity of the two electromagnets. (corresponding to Figure 5C)

it reached an altitude of 10 km. This was due to the high density of the region. The altitude controller was able to regulate the spinning speed of the four motors and ensure a soft landing on Venus. The entire flight time was approximately 14,200 s, as shown in Figure 11. Note that the vertical and horizontal velocities of the multirotor lander can be regulated using the altitude and attitude controllers for stable and soft landings. The use of lightweight plastic deformable material as the landing base[55,56] for soft landings along with proximity sensors attached to height-adjustable legs are recommended herein for future planet landers to complete the planet exploration lucratively.

3 | DISCUSSION

The proof of concept presented herein established the technical feasibility of dual-head EMP systems for various future holistic and responsible uninterrupted industrial applications. It includes the lucrative design of autonomous crafts for earth and planetary explorations. Note that simultaneously dropping multiple identical Landers with the variable spinning speed rotor governed by the feedback control system of the EMP device could generate useful data for planet environmental studies on essentially its fluid dynamic aspects, as well as the gravitational forces. It will shed light on inventing future manned and unmanned space exploration vehicles and landers on the way to the corridor of an undiscovered planet. We could decisively prove the proposed concept through the static test of a push-pull EMP system. Laboratory static tests (please see the supplementary material as Movies S2, S3, and S4) corroborated that the purported EMP system can be utilized for rotating the deep space propulsion probe for the planetary voyaging with the aid of a mighty lunar[53] or solar cell for a high endurance application. The efficiency and endurance of the EMP system can be improved by increasing the size of the unit, which would allow for a wider range of interdisciplinary applications across different industries for energy conversion and harvesting purposes. Admittedly, the proposed EMP system is ecologically benign, with no fuel burning; moreover it is highly competent because the device has fewer moving parts. Various in-house tests are successful for the miniature EMP system. It could be minuscule more for various micro/nanoscale applications including the development of microelectromechanical system gravimeters[6] for Earth tide measurements.

The MagLab team has developed a miniature electromagnet that weighs just 390 g and is less than a centimeter thick, yet it generated a world-record 45.5-tesla magnetic field. Such creative technology has the potential to revolutionize the industry by enabling small magnets to perform large-scale tasks in the future through the fourth industrial revolution.

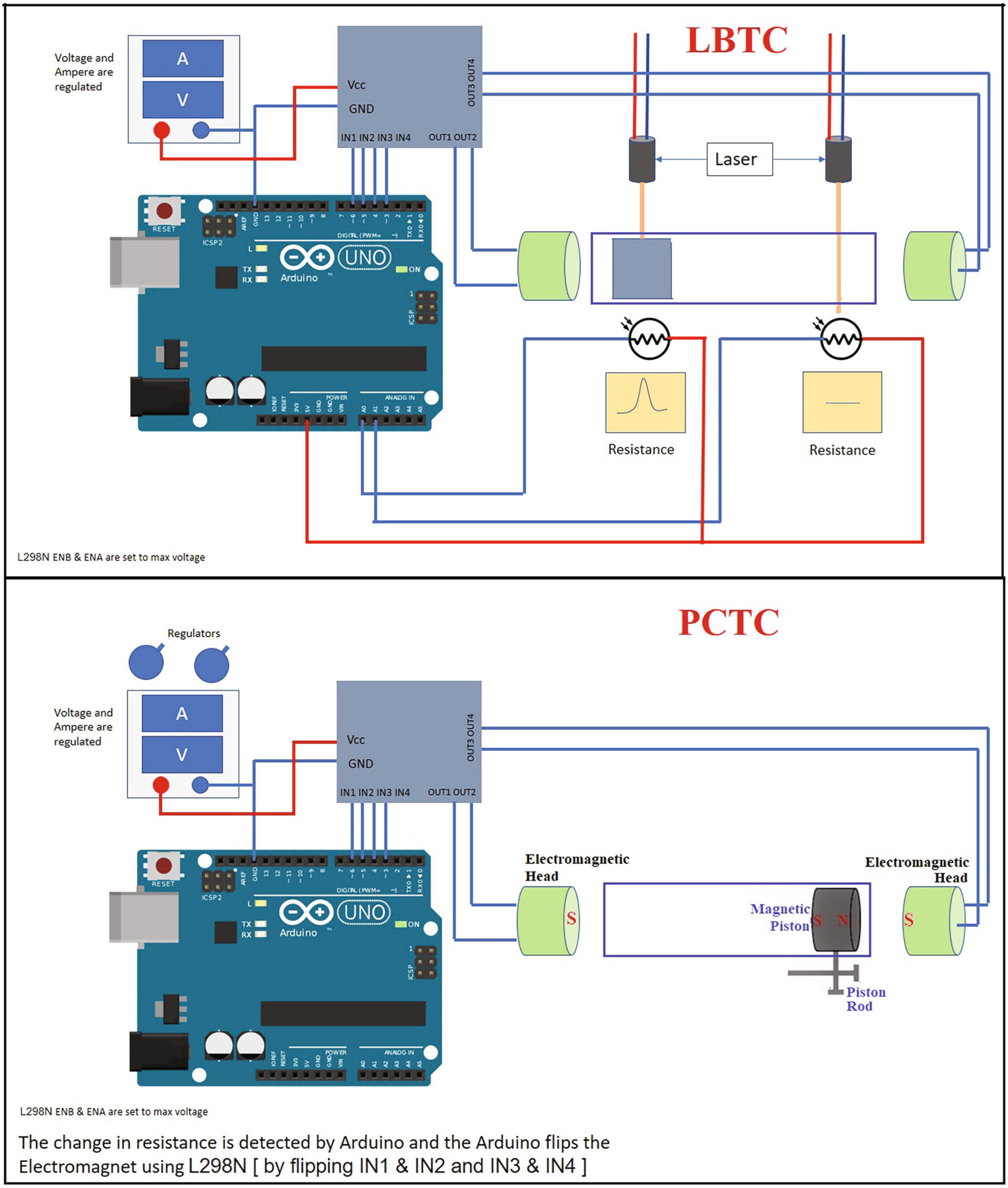

FIGURE 9 Circuit diagram of the LBTC/PCTC (please see the test video of the ground static test of the EMP device in the supplementary material as Movie S3). (see Movie S4: Laboratory qualification test of laser based timing circuit: https://youtu.be/2YG6azBMQQo)

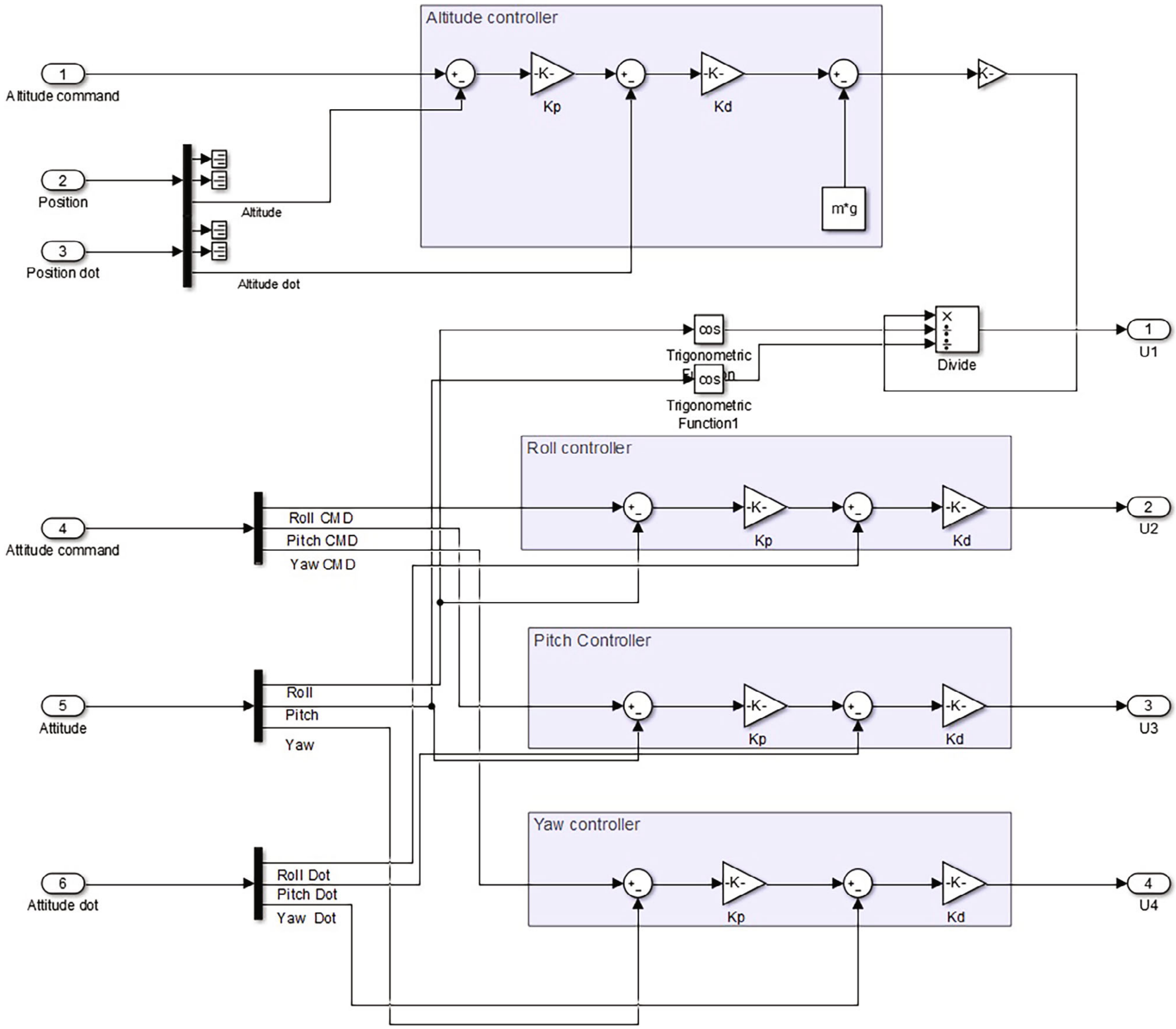

FIGURE 10 A model that controls altitude, roll, pitch, and yaw of a vehicle.

Since this article aims to prove the concept, scaling issues are not addressed.[2,8] The fact is that the yocto scale magnet has yet to be realized in the industry for establishing the scaling law, which is beyond the scope of this article.

The newly invented multipurpose push-pull dual-head EMP system regulated with PCTC/LBTC is a unique propulsion and energy harvesting system ideally suited for unrestricted flight endurance. It is well known that multicopter rotorcraft are less vulnerable to turbulence than similar sized fixed wing aircraft. The report reveals that traditional drones disinfect 80,000 square meters in a day, requiring negligible manpower and covering all nooks and corners of the city. In summary, the push-pull EMP system equipped drone has unlimited endurance and can be used to deliver drugs or food to people under quarantine during the day and night, making it a potential solution during the COVID-19 pandemic.[57] The recent discovery of Kumar et al.[29,44,58] pertaining to healthcare management revealed that aerial robots regulated with the EMP system could be used for fostering pharmaceutical florae[27,29] in the international space station for drug discovery.[29,44,58,59] All these deliberations establish that the reciprocating movement of a magnetic piston into rotary motion using PCTC/LBTC can generate continuous power for various multidisciplinary applications on Earth, international space stations, and other planets, effectively replacing long-lasting rechargeable batteries. These discussions establish the potential of the push-pull dual-head EMP technology for generating continuous power in various industrial applications.[45–49,58,60–68]

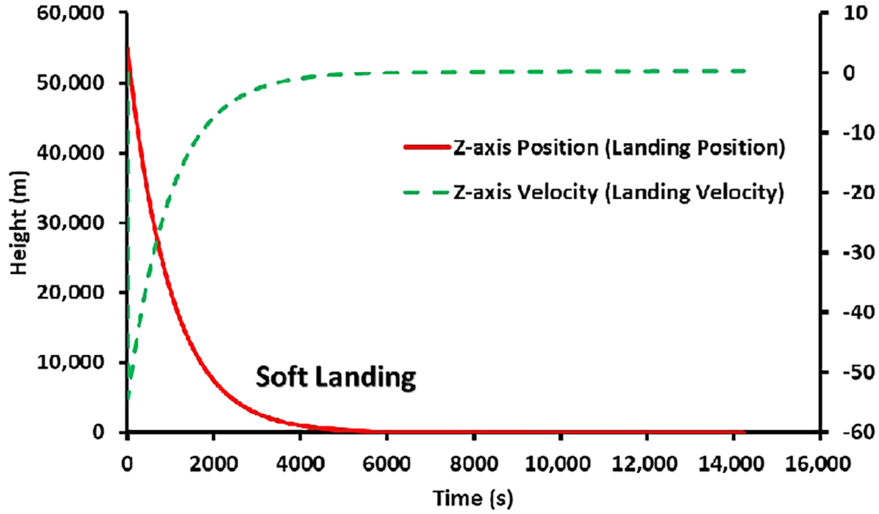

FIGURE 11 Z-axis velocity and position of the quadcopter lander.

4 | CONCLUSIONS

We could conclusively prove the proof of the concept of push-pull dual-head electromagnetic propulsion and energy conversion systems for future holistic uninterrupted industrial applications. Electromagnetic propulsion systems can be a base for the next generation energy conversion systems for various applications from underwater to the outer space. This article presents a static test model that demonstrates the unrestricted reciprocating movement of a magnetic piston using a polarity changing timing circuit. The test was successful, and we have demonstrated the feasibility of our concept. The electromagnetic propulsion and energy conversion system, which utilizes a dual-head configuration, is a novel device that shows promise in generating uninterrupted power and storing energy for a range of industrial applications in physical, chemical, biological, and environmental sciences. This system is a new addition to the global scientific community and patently a promising device for various multidisciplinary applications. The proposed concept can also be utilized for designing biomedical devices, energy materials, and nanomaterial-enabled locomotive applications, resulting in significant scientific and technological advancements that can benefit humanity.

AUTHOR CONTRIBUTIONS

Sanal Kumar VR: Conceptualization (lead); data curation (lead); formal analysis (lead); funding acquisition (lead); investigation (lead); methodology (lead); project administration (lead); resources (lead); software (lead); supervision (lead); validation (lead); visualization (lead); writing – original draft (lead); writing – review and editing (lead). **Amrith Mariappan:** Conceptualization (supporting); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (lead); visualization (lead); writing – original draft (supporting); writing – review and editing (supporting). **U. K. Thianesh:** Conceptualization (supporting); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); project administration (equal); resources (equal); software (equal); supervision (equal); validation (equal); visualization (equal); writing – original draft (supporting); writing – review and editing (supporting). **Ajith Sukumaran:** Conceptualization (supporting); data curation (equal); formal analysis (equal); investigation (equal); methodology (equal); project administration (supporting); software (equal); validation (equal); visualization (equal); writing – original draft (supporting); writing – review and editing (supporting). **Ashish Kumar:** Conceptualization (supporting); data curation (equal); formal analysis (supporting); investigation (supporting); methodology (equal); software (equal); validation (equal); visualization (equal); writing – original draft (supporting). **V. K. Vijil Lal:** Conceptualization (equal); data curation (supporting); formal analysis (supporting); investigation (supporting); methodology (supporting); resources (equal); validation (equal); visualization (equal); writing – original draft (supporting). **Jerin John:** Conceptualization (supporting); data curation (supporting); investigation (supporting); validation (equal); visualization (supporting);

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ACKNOWLEDGMENTS

Sanal Kumar VR thanks the Defense Research and Development Organization, Ministry of Defense, Government of India for the necessary support for originating this historic work under grand-in-aid research proposal to the Aeronautics Research & Development Board (File No. ARDB/GIA/2022/000009), New Delhi, India.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

PEER REVIEW

The peer review history for this article is available at https://www.webofscience.com/api/gateway/wos/peer-review/10.1002/eng2.12703.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available within the article.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: VR SK, Mariappan A, Thianesh UK, et al. The proof of concept of uninterrupted push-pull electromagnetic propulsion and energy conversion systems for drones and planet landers. *Engineering Reports*. 2023;e12703. doi: 10.1002/eng2.12703