DESIGN AND IMPLEMENTATION OF AN AUTOMATED TOILET IN MECHANICAL ENGINEERING RESTROOM

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CERTIFICATION

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DEDICATION

This project work is dedicated to God Almighty who granted us the patience and courage to perform and carry out this project work, without his help, we would not have been able to have achieved what we have done thus far.

This project is also dedicated to our ever loving parents for their unwavering support, sacrifice, guidance and prayers throughout the duration of our course of study.

ACKNOWLEDGEMENT

First off, we would like to express our sincere gratitude to our project supervisor, Engr. P.O. Olagbegi who took us under his wing not only as his project sudents but more like his children, his guidance and instruction was nothing but inspirational during this project. Under his guidance we were able to gain knowledge about automation as a whole while we completed this project successfully. His regular reviews of the project work helped us identify the flaws in our work while setting important milestones for this project.

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We won't fail to also express our deep appreciation to all members of staff of the department of Mechanical Engineering, under the visionary leadership of Prof. E.G. Sadjere, University of Benin, Benin city.

Finally, our warmest thanks and gratitude goes to our loving parents, who have always been by our sides from the very first steps we took in life while helping us overcome the various challenges and difficulties each of us had to face. Their encouragement, love and our unwavering determination to make them proud was definitely our biggest source of motivation. We would like to take this time out to thank them immensely for their support, both financially and otherwise.

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ACRONYMS

- AC – Alternating Current
- AGC – Automatic Gain Control
- BMS – Battery Management System
- DC – Direct Current
- IR – Infrared
- IoT – Internet of Things
- LED – Light Emitting Diode
- LDR – Light Dependent Resistor
- MQTT – Message Queuing Telemetry Transport
- MSD – Motion Sensing Device
- PIR – Passive Infrared
- PWM – Pulse Width Modulation
- RF – Radio Frequency
- UV – Ultraviolet
- VLS – Visible Light Sensor
- RFID – Radio Frequency Identification

ABSTRACT

The unending evolution of technology has led to the innovations in everyday facilities, and restroom infrastructure isn't left out. This project focuses on the DESIGN AND IMPLEMENTATION OF AN AUTOMATED TOILET for the Mechanical Engineering Department of the University of Benin. This automated toilet integrates automation, hygiene, and efficiency-enhancing features to improve user experience, environmental sustainability, and operational convenience.

The system incorporates a limit switch which sends signal to the modified autoflush device whenever a user opens the door, contactless flushing, odor detection, water efficiency mechanisms, enhanced hygiene protocols and a automated lock which incorporates both biometrics and a card reader to enforce access control. The design process involved conceptualization, material selection, fabrication, and performance testing. All ensuring optimal functionality in the university environment.

The Testing results indicated that the automated toilet performed efficiently, with responsive automation and reliable hygiene features being implemented to foster a contactless user experience. The implementation of this system demonstrates the potential of automated restroom solutions in the enhancement of sanitation, water wastage, while also providing a modern, user-friendly facility. Some future improvements could include ultrasonic sensors for higher precision, improved water conservation strategies, and also more compact design elements. This project highlights the role of automated technology and modification in modern sanitation and its potential for broader applications in both public and private facilities.

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND TO THE STUDY

One of the characteristics of man is the discharge of biological wastes through urination, defecation, sweating and other biological means of wastes discharge. Defecating and urination by man in particular has been carried out in various ways over time using different methods such as open space defecation, use of latrines, masonry sit on and even water body defecation. These conventional methods posed a lot of challenges which include unhygienic process (Dharmesh et al, 2018), environmental pollution, inconvenience to use, lack of privacy, user discomfort and health challenges resulting from exposure to bacteria. Over the years owing to advancement in technology, life changing patterns and the need to proffer solutions and revolutionize many aspects of human daily lives, including household amenities, man sought to explore automated technologies which is a trend in modern day (Tejas, 2024). Among these technological advancements, the automated toilet stands out as a significant innovation in improving hygiene, comfort, and efficiency in restroom facilities.

AN AUTOMATED toilet is a bathroom plumbing fixture or type of electronic toilet which incorporates traditional cleansing (for genital, buttocks and anal hygiene), with the added enhancement of modern automated home technology. By integrating advanced features such as automated flushing, heated seats, bidet functionality, and health monitoring, automated toilets offer a superior user experience and address various needs of modern households. automated toilet functions are managed through voice command, mobile app or remote control navigation. Advanced sterilization technologies ensure toilets stay pristine while neutralizing harmful germs for peace of mind. The versatility of the automated toilet has made life easier for not just the young but the elderly people and individuals with disabilities

who often face significant mobility challenges due to bone system degradation or various afflictions. Solutions that improve the quality of life for these individuals are highly valuable as the automated toilet is a significant technology designed for such purposes in the present day. Figure 1.1 shows a typical automated toilet.

Figure 1.1 automated Toilet

automated offer a range of high-tech features that enhance the bathroom in many ways which include

i. Automatic flushing
ii. Touchless operation to reduce germ transmission
iii. Water efficiency for conservation

automated toilets use technology to automate functions and reduce sanitary concerns, while fostering a good user experience. The growth of Internet of Things (IOT) referred to as a daily technological innovation wh1ch involves devices connecting to one other to create a pervasive computing (Feng et al, 2018) has also contributed to the sophistication of the automated toilets due to the ability for these systems to exchange data and information about users and the environment, while automatedly reacting independently to different events and tasks (Jabbar et al., 2018).

1.2 STATEMENT OF THE PROBLEM

Conventional methods of defecating and urinating which include open space defecation, use of dug latrines, water body defecation and urination are froth with anomalies which include unhygienic practice, compromised privacy, inconvenience and exposure to bacterial. The modern day mechanical toilet also inhibits efficient user experience especially to the elderly and muscular impaired users who require aid to use such facility. To proffer solution to such anomalies to enhance user experience, local development and cost effectiveness, it has become pertinent to develop automated toilets suitable for use in places of human dwellings such as schools, offices, hospitals, museums etc. The rest room of the mechanical engineering department of the university of Benin for example is used as case study as it requires a modern upgrade owing to the need for improved hygiene, Operational Efficiency and User Experience. To achieve these, AN AUTOMATED toilet is therefore proposed to provide advanced features and functionalities that will enhance the overall restroom experience for students, staff and visitors of the department.

1.3 AIM AND OBJECTIVES OF THE PROJECT

1.3.1 AIM OF THE PROJECT.

The aim of this project is to develop, install and test an automated toilet in the mechanical engineering department of the University of Benin.

1.3.2 OBJECTIVES OF THE PROJECT.

The objectives of the research are to:

i. Develop a concept of an automated toilet
ii. Select appropriate materials to install an automated toilet.
iii. Install the automated toilet.

iv. Test and evaluate the performance of the automated toilet.

1.4 SIGNIFICANCE OF THE PROJECT

This project of developing an automated toilet in the mechanical engineering department is significant in promoting environmental hygiene, enhanced user experience, comfort and convenience. The study of automated toilets will be significant to expository learning and research. Automated toilets will enhance cost efficiency in toilet maintenance as cleaners will find it easier to clean and less maintenance will be provided as user device interface is reduced.

1.5 METHODOLOGY OF THE PROJECT

The method of approach of the projects is highlighted as follows:

i. Acquisition of data
ii. Conceptual design
iii. Materials selection.
iv. Creation of the proof of concept
v. Testing and evaluation of the concept
vi. Conclusion

CHAPTER TWO

LITERATURE REVIEW

2.1 REVOLUTION OF AUTOMATED TOILETS: CONVENIENCE AND HYGIENE

The humble toilet has come a long way since its origins thousands of years ago. Once just a communal latrine or hole in the ground, today's toilets have evolved into sophisticated automated toilet systems integrating advanced technology for the ultimate in comfort, convenience, and hygiene. Intelligent toilets are revolutionizing the bathroom experience. Different from traditional sanitary products, automated sanitary products integrate ceramic production, electronic control and automation technology in many fields to enhance the experience of sanitary products. Among the many automated bathroom products, the automated toilet product (Zakaria, et al, 2018) has become the most representative. Its appearance has brought a major product reform feast to the bathroom industry.

Automated toilets have evolved significantly over time, driven by advancements in technology and the desire for improved hygiene, convenience, and comfort. Here's a brief history:

Early Innovations (Ancient Civilizations): The earliest flushing toilets, developed by the Romans, were manually operated, relying on running water and basic plumbing systems.

1900s - The Modern Flush Toilet: The modern flush toilet was popularized by figures like Thomas Crapper and Joseph Bramah. These toilets were manually operated, requiring human effort to flush.

1950s - Early Automation: The first steps toward automation included the introduction of pedal flushes and automatic valves, which began reducing manual effort.

1960s - Electronic Flushing: Japan introduced early electronic sensors, marking the beginning of automated flushing mechanisms that were triggered by sensors to detect when a user finished.

1970s - Basic Automation: In Japan, TOTO released the first **Washlet** toilet system, incorporating automatic flushing, heated seats, and bidet functions, setting the foundation for modern smart toilets.

1980s - Advanced Features: Smart toilets began incorporating additional features like adjustable water pressure, seat heating, and air dryers. TOTO expanded its **Washlet** line internationally.

1990s - Smart Toilets: The term "smart toilet" emerged with the introduction of high-tech systems, including remote control, night lighting, and advanced self-cleaning mechanisms.

2000s to Present - Cutting-edge Technology: Today's automated toilets feature voice control, integrated health monitoring, air purifiers, and water-saving technology. Leading brands like TOTO, Kohler, and American Standard continue to innovate in this space, focusing on comfort, convenience, and environmental sustainability.

2.2 COMMON AUTOMATED TOILET FEATURES AND INNOVATIONS

State of the art toilets intelligent toilets are now defined by features such as:

Touchless Flushing - Motion sensor triggers automatic flushing after use for hands-free operation.

Automatic Opening/Closing Seats and Lids - Seat lifts as you approach and lowers automatically after use via proximity sensors.

Self-cleaning wands extend to sanitize the bowl before and after each use (Elavaras et al., 2018).

Heated Seats - Warm the seat to your preset desired temperature for comfort in the winter.

Built-In Bidets - Adjustable warm water sprays assist with personal cleansing after use.

Air dryers in seats eliminate the need for toilet paper.

Variable Temperature Control - Adjust heated seat, bidet water temperature, and warm air drying temperature to your preference.

Store user profiles.

LED Ambient and Night Lighting - Underwater bowl lights, footwell illumination, and dimmable mood lighting set a relaxing ambiance.

Touchscreen Remote Controls - Control all functions via intuitive touchpad remote.

Intelligent toilets adapt to users automatically for maximum convenience while optimizing cleanliness and comfort.

2.3 HIGH-TECH TOILET HYGIENE INNOVATIONS

automated toilets in general employ cutting-edge hygiene technologies which include the followings:

i. **Antimicrobial Surfaces** - Toilet bowl and seat surfaces infused with silver nanoparticles or other coatings kill microbes on contact.

ii. **UV-Light Sterilization** - UV lamps sterilize the bowl before and after use to kill harmful bacteria and viruses including cold and flu viruses. Only activates when unoccupied to be safe.

iii. **Electrolyzed Water Sterilization** - The flow of electrolyzed water with its disinfecting properties keeps bowls clean with every flush.

iv. **Self-Cleaning Wands** - Automated self-cleaning wands extend from under the toilet rim to sanitize inner bowl surfaces completely before and after each use.

v. **Hands-free Automatic Flushing** - Motion-activated flushing allows toilet use without ever touching surfaces.

Advanced sterilization technologies ensure toilets stay pristine while neutralizing harmful germs for peace of mind.

2.4 AUTOMATED TOILET DESIGN OPTIONS

Intelligent toilet designs include the followings:

i. **One-Piece Toilets** - Entire toilet housed in a seamless single chassis for straightforward cleaning. No grooves and crevices.

ii. **Two-Piece Toilets** - Separate bowl and tank components allow customized combinations but can trap germs in crevices.

iii. **Elongated Bowls** - Extended oval shape for maximum comfort and accessibility.

iv. **Rectangular Design** - Contemporary style with a sleek, space saving rectangular silhouette.

v. **Tank less Design** - No tank minimizes space requirements.

vi. **Wall Hung Bowls** - Install directly on wall with no contact with floor for easy cleaning underneath.

While automated toilets come in all styles, one-piece seamless bowls best facilitate thorough cleaning and hygiene. While automated toilets largely maintain themselves, some maintenance tips are needed for their optimal performance such as:

i. Keep the remote control dry and away from moisture.
ii. Clean touchscreen remotes with a microfiber cloth only to avoid scratches.
iii. Descale spray jets and disinfect their housing monthly to prevent buildup.
iv. Regularly replace air purification filters.
v. Install fresh toilet deodorizer bricks in the holding tank every 2-3 months.
vi. Update automated toilet software when new versions are available.
vii. Disinfect the toilet brush holder regularly and allow brushes to dry between uses.

2.5 EVALUATING AUTOMATED TOILET OPTIONS

Factors that are necessary when considering AN AUTOMATED toilet, include the following factors:

i. **Features** - Determine must have's vs. nice to have's. More complex equals higher price.
ii. **Style** - One or two piece; wall hung or floor mount; round or elongated bowl?
iii. **Dimensions** - Measure space allowed. Larger units require more clearance.
iv. **Power Needs** - Electrical outlet must be nearby. More features require more wattage.

v. **Plumbing** - Existing lines may need to be adapted for bidet jets.

vi. **automated Home** - Do you want app or voice control integration?

2.6 RELATED LITERATURES

Atharv et al., (2024) developed AN AUTOMATED toilet system for cleanliness and user satisfaction which they termed an invention towards the future of public restroom. The project was aimed at making public restrooms self-cleaning using an automated system which uses various IoT sensors such as MQ-135 sensor, LDR sensor. The authors asserted that people's lack of interest in maintaining clean public sanitation systems in comparison to their degree of concern for maintaining clean restrooms at their houses was the primary cause of the current state of sanitation and wasting public funds in maintaining hygiene and cleanliness in public washrooms. To address the issue, the authors developed AN AUTOMATED toilet system that used various sensors and an app-based interface to facilitate efficient washroom management.

Dharmesh et al., (2018) constructed AN AUTOMATED toilet. The authors asserted that cleanliness in the railway system of India was one of the motivating factors for the design of the automated toilets which were to be installed in the countries trains. The authors also asserted that unclean toilets in India's railway system caused contagious diseases which were hazardous for human life, hence the need for developing automated toilets with the help of IOT. The proposed system automatically cleaned the squat pan toilet with the help of robotic arm. The robotic arm had a brush attached to its end effector which was used for the cleaning purpose. The system used minimum amount of water & electricity. Auto door locking system was provided during the working of the system to avoid human interference. To maintain the periodicity of cleanliness level different kind of sensors were used. A database was maintained which gave all the notifications to authorities of cleaning department of railway on a web page and an android application by using Wi-Fi.

The Guardian, (2022) which conducted a study on “The automated toilet era”. The study highlighted some features of automated toilet to include: electronic bidet shower for front and rear cleansing, Seat-warming, Adjustable water temperature, Deodorizer, Air dryer, water-conservative fixtures and Illuminating nightlight

Quispe et al., (2024) developed and implemented automated toilets as an innovative business model in public and private institutions

Marshall and Bryan (2016) asserted that modern intelligent toilets incorporate electronic bidet cleansing functions into a ceramic toilet bowl for a low-profile and modern aesthetic. Intelligent toilet bidet functions are managed through voice command, mobile app or remote control navigation, depending on the toilet's manufacturer, make and model.

Tejas et al, (2024) developed AN AUTOMATED toilet using microcontroller. The authors asserted that despite significant technological advancements in the modern world, the issue of cleanliness remained a critical concern hence maintaining uncontaminated public toilets was crucial to the success of hygienic defecation initiative. The automated toilet was developed to help prevent various health issues and raise public awareness about effective toilet management, contributing significantly to the Clean India project. The automated toilet designed by the researchers utilized a controller-based system equipped with various sensors, including IR sensors, switches, batteries, and servo motors.

Elavaras et al., (2018) developed automated toilets using IOT. The authors motivation was the need to keep clean hygienic toilets. The development of the automated toilet by the authors was to design safe and hygienic toilets based on IOT and image-processing concepts using different sensors like smell sensor, IR sensor, sonic sensor, RFID reader.

Kitisak et al., (2017) proposed a configurable automatic automated urinal flusher based on MQTT

Protocol. The research paper examined a probable way to cut the wastage of clean water used in a public toilet. The system utilized a MQTT as an underlying communication protocol. The protocol was used in gathering, governing, powerful and correcting the system. The results in the testing environment showed that using a flushing duration for 2.5 seconds was enough to satisfy most users while wasting clean water as reduced as possible.

Teddy and Istonio (2018) developed a water level detection in AN AUTOMATED home bathtub using ultrasonic sensor and fuzzy logic. The device used water level detection to save water with an automated mechanism that opens and closes the water-tab. After the bathtub was filled with water, the automated house determined to turn off the water supply automatically. It made use of an ultrasonic sensor to gauge the water level. When the sensor detecting the water surface closed, the ultrasonic sensor, alerted the user to a rising water level and turn off the water supply before a flood happened.

Mithya et al., (2019) discussed the application of cutting-edge technologies, including the use of an Arduino Uno, a GSM module, an IR sensor, a turbidity sensor, and a gas sensor in producing clean automated toilets. The design was capable of monitoring the work of the sweeper, and prohibiting the use of unclean facilities. Modern technologies such as solar energy to generate electricity was used to build the intelligent public restrooms.

2.7 LITERATURE GAP

The gap in literature in the reviewed works on automated toilets is that none of the literatures have explored automated toilet designs tailored to the prevailing conditions of the faculty of engineering at the university of Benin environment. User experiences, needs and weather conditions may differ from place to place hence not many automated control features might be required for specific designs. Say a winter warmer for toilets may not be necessary in a place like Nigeria which is a temperate region. The present research therefore intends to

explore the development of AN AUTOMATED toilet with due considerations to the prevailing conditions and user experiences in the faculty of engineering.

CHAPTER THREE

MATERIALS AND METHODS

3.1 MATERIALS

The materials assembled for the production of the automated toilet system are listed in the Table 3.1.

Materials	**Function**
Smart Lock	It is an electronic locking device that aids access control to the toilet without the need for traditional keys. Instead, it uses technologies like Bluetooth, Wi-Fi, or biometrics (fingerprints, face recognition) for keyless entry.
Auto-flush Device	It is a sensor-based mechanism installed in toilets to automatically trigger a flush after use, eliminating the need for manual operation.
Hand Drier	It is an electrical device used to dry hands after washing, typically found in public restrooms. It uses either warm air or high-speed airflow to remove water from the hands.
DC Battery	A DC (Direct Current) battery is a power source that stores and supplies electrical energy in the form of direct current.
Battery Charger	It is used to charge the DC batteries being used to power the auto-flush device
Limit switch	Limit switches are used to detect the presence or absence of an object.
LED lights	For illumination and power signal
Arduino Mega (Nano)	It is a central processing unit of the automated security device.
Structural support	This is made of the metal/wood or masonry material which act as a mounting support for the toilet and electronic systems.
Wires/auxiliary accessories	Used for components interconnectivity.

Table 3.1 Materials Required for the Production of automated Toilet.

3.2. METHOD

3.2.1 CONCEPTUAL DESIGN.

The automated toilet system is meant to automatically detect the presence of a user once the door opens. The user proceeds to use the toilet for defecating or urinating after which the auto-flush device receives the signal to initiatea flush once the user opens the door. The flush pattern and the amount of water utilized is guided by the flush of either feces or urine or both as the case may be.

The schematic of the proposed automated toilet is shown in the Figure 3.1.

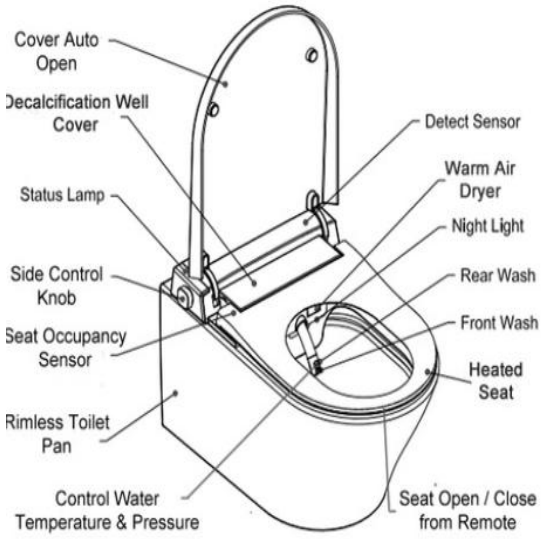

Figure 3.1 Schematic of automated Toilet

The flow diagram of the automated toilet system design is shown in Figure 3.2

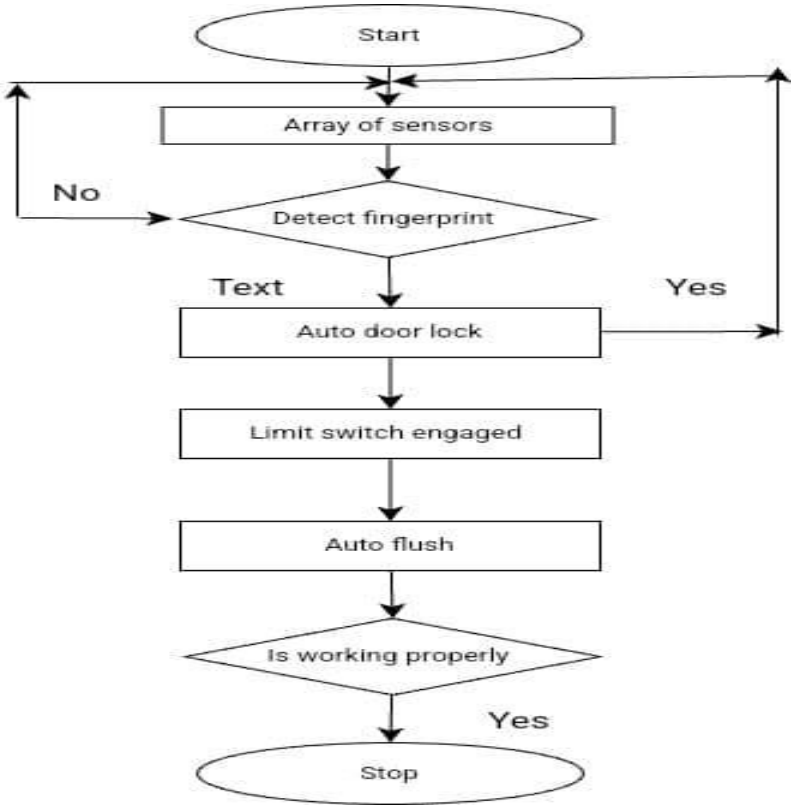

Figure 3.2 Flow diagram of the automated toilet system design

3.3 DETAIL DESIGN

3.3.1 INPUT VARIABLES FOR MATERIAL SELECTION

i. User detection range (variable) max 10m

ii. Heat sensitivity from humans (ambient temp. 32^{o}C)

iii. Number of PIR motion detecting light sensors: 2

iv. Operating voltage: 12V dc, 110-240V AC.

v. Water requirement in volume for flush (2liters)

3.3.2 ENERGY AUDIT FOR THE ELECTRIC POWER REQUIREMENT OF THE TOILET

Total power requirement for the system =

3 PIR MSD x 10 = 30W

Auxiliary accessories = 30W

Water pump = 8W

PIR sensor 5W

LED lights = 6W

3.3.3 Power Supply Unit

Battery with BMS: The battery capacity shown in Figure 3.3 varies, with common options including 2000mAh or 3000mAh. The Battery Management System (BMS) includes crucial protection features such as overcharge protection, over-discharge protection, and short-circuit protection.

Figure 3.3 Battery with BMS

The peak secondary voltage, $V_{peak} = \sqrt{2} \times V_{rms}$ (3.1)

A bridge rectifier diode rectifies the 14V from the secondary of the step down transformer. The full-wave bridge rectifier 5W001 was used because it has a peak inverse voltage of 50V and can pass a peak current of 2A which is suitable for the circuit design.

$V_{L(peak)} = V_{(max)} - 2V_{d(on)}$ (3.2)

For a suitable filter capacitor value to be employed the following calculations was considered

$$V_r = \frac{I_O}{2f_c} \quad (3.3)$$

where

Vr = ripple voltage =1v

F = frequency = 50hz

I_o = regulator output current = 250mA

The capacitance *C* of the capacitor is therefore expressed as:

$$C = \frac{I_0}{2fvr} \quad (3.4)$$

Arduino Uno:

A Microcontroller shown in Figure 3.4 is used ATmega328P. Its operating voltage is 5V. Digital I/O Pins is 14 (of which 6 provide PWM output) and Analog Input pins: 6. A Flash Memory is32 KB (of which 0.5 KB is used by the bootloader) and Clock Speed is 16 MHz. Light emitting diode (Indicator).

Figure 3.4 Adruino Uno

A LED is connected in the circuit to indicate that there is power in the circuit. A resistor is connected in series with the light emitting diode. The resistor limits the amount of current entering the LED. The value of the resistor is determined as follows:

$V = V_d + IR$

(3.5)

Where

V = supply voltage

V_d = voltage of LED

I = allowable current through the LED

Modified Auto-flush Device:

An **auto flush device** functions automatically to flush the toilet after use without the need for manual intervention. Here's a brief breakdown of its function:

Detection: The device is connected to a Limit Switch (Via wires) to detect when the user opens the door. Some systems may also use weight/heat sensors to determine occupancy.

Triggering the Flush: Once the user opens the door, the limit switch is triggered which inturn sends the signal to the auto-flush device to trigger the flush mechanism. The flush is activated by a valve opening to release water into the bowl, clearing waste.

Optional Adjustments: Advanced systems may include settings for time delay and different flush volumes based on waste type, saving water when possible.

Post-Flush: After flushing, the system will reset, while getting ready for the next use.

The sole aim is to provide a hands-free, hygienic, and water-efficient solution for flushing the toilet.

Figure 3.5 Modified Auto-flush Device

DC Battery Charger:

A **DC battery charger** is designed to recharge rechargeable batteries (such as lithium-ion, nickel-cadmium, or lead-acid) by supplying direct current (DC) voltage and current to restore energy to the battery. This battery charger is used to keep the batteries charged as an alternative power supply to keep the devices running even in a case of power outage

Figure 3.6 DC Battery Charger

Limit switch:

Limit switches are used to detect the presence or absence of an object. A limit switch shown in Figure 3.7 is an electromechanical device operated by a physical force applied to it by an object.

Figure 3.7 Limit Switch

Smart Lock:

A smart lock is a keyless electronic lock that allows a user secure and unlock doors using biometric recognition (like a fingerprint) or a card reader. Smart locks often come with features like temporary access codes and activity tracking. Offering enhanced convenience, security, and flexibility compared to traditional mechanical locks.

Figure 3.8 Smart Lock

Hand Drier:

The hand dryers found in public restrooms are electric devices used for drying hands after washing. Basically, it works by blowing a stream of warm or cool air onto hands to remove moisture. The user activates the dryer by placing their hands under a sensor. Commonly found in restrooms, hand dryeres are an eco-friendly alternative to paper towels, reducing waste and need for frequent towel refills.

Figure 3.9 Hand Dryer

The Transmitters:

Two transmitters are selected with different frequencies. These frequencies are distinctly different to avoid jamming of signals, because environmental noises oscillate at frequencies the receiver could be picked up if not conditioned (Wayne et al, 2012). Timers are configured as stable multi-vibrators, infra-red LEDs and transistors as drivers. A stable multi-vibrator is to generate a tone frequency and then modulates the infra-red beam, to generate modulated beam. The pulses are connected to infrared diodes through a pair of Darlington transistors to give the required signal amplification. The light beam emitted from the IR diode is focused to the receiver.

The transmitter range is expressed as:

Min RX level + RX antenna gain - RX transmission line loss +TX antenna gain -TX transmission line loss + TX power= Free Space Path Loss (maximum acceptable). (3.10)

The range equation relates the received RF signal power to the transmitted signal power, as a function of frequency with wavelength expressed by the Friis equation as:

$\lambda = \frac{c}{f}$ and distance (D) between transmitter and receiver antennas.

$$Pr = \frac{P_t G_t G_r}{1} \left[\frac{\lambda}{4\pi D}\right]^2 \quad (3.7)$$

where:

Pr = the power received at the receiving antenna in watts

Pt = the power transmitted from the transmitting antenna in watts

Gt = the gain of the transmitting antenna

Gr = the gain of the receiving antenna

lambda = wavelength of the signal in meters

D = distance between the transmitting and receiving antennas in meters

Receivers:

The infrared receiver is implemented using infrared receiver module developed for frequencies reception between a range of frequencies. The receiver consists of infrared receiver photodiodes, AGC (automatic Gain Control), Band pass, and a demodulator. The receiver absorbs the infrared emission from the transmitters and converts it to electrical signal, which is forwarded to the central console of the automated system.

The receiver power is expressed as:

$$R_p = \frac{G}{f^2 \, x \, D^2} \quad (3.8)$$

where:

G = antenna gain by the transmitted power,

f = frequency

D = propagation distance.

The

Visible Light Sensor Unit

The VLS detects visible light. The light dependent resistor LDR was used for the circuit design. Two voltage divider networks are in the circuit. The first consist of two type, R1 (10kΩ) and LDR. The second is the 4.7kΩ) and a variable resistor (10kΩ) . The first pair produce an unfixed voltage at the + Pin of the IC. At every change in light intensity of light falling on the LDR, the voltage will drop across the + pin of the comparator. The higher the intensity of light on the LDR, the resistance will be hence the lower the voltage drop across it.

74151 Multiplexer:

These 74151, 8 to 1 line multiplexers are used in the central console unit for power and reset functions, respectively. The multiplexer input terminals are scanned sequentially at a frequency dependent on the clock in order to pick up the signal on its line. The power multiplexer is used to detect the ON mode of the different terminals. The signal multiplexer is used to ascertain which of the terminal picked up a breach.

The equation for the multiplexer can be represented as:

$$Y = S_1S_0I_0 + S_1S_0I_1 + S_1S_0I_2 + S_1S_0I_3 \quad (3.9)$$

The number of selection lines required for a multiplexer with N input lines is:

$\log_2(N)$ selection lines 1.`

3.4 BILL OF ENGINEERING MATERIALS AND EVALUATION

The bill of engineering materials and construction of the toilet is presented in Table 3.2.

S/N	Materials	Description	Size	Quantity	Unit cost (N)	Total cost (N)
1	Water closet			3	75,000	225,000
2	Wash Hand Basin			1	50,000	50,000
3	Urinal			1	45,000	45,000
5	Battery			2	15,000	30,000
6	Batter Charger			1	50,000	50,000
7	Auto-flush Device			4	30,000	120,000
8	automated Lock			1	175,000	175,000
9	Door			1	50,000	50,000
10	Partition Boards			3	50,000	150,000
11	Limit switch			3	2,000	6,000
12	Glass			1	49,000	49,000
13	Labor	Lump sum			95,000	95,000
14	Wiring	Lump sum			80,000	80,000
15	Miscellaneous				100,000	100,000
	Total					1,225,000

Table 3.2 Bill of Engineering Materials and Evaluation of the Toilet System

The pictorial view of the build security alert system is shown in Figure 3.10

3.5 CONSTRUCTION AND TESTING OF THE SYSTEM

The automated toilet was constructed in accordance with the circuit and flow diagrams in section 3.1. The design was simulated on an electronics work bench. The testing followed the modular pattern used in the design with each functional block being tested. Various workshop production techniques such as cutting, machining, filing, bracing, soldering were used in carrying out the entire modificaion and installaion process.

3.6 TESTING OF THE AUTOMATED TOILET

The testing of the automated toilet was commenced by system initiation where the power was switched on and all components verified to be in good working condition. A user was then instructed to use the toilets at random to evaluate the performance of the individual fixtures of the toilet.

The Auto-flush device was tested for the output voltage level. The entire circuit was tested for short circuit and open circuit faults that could result into problems. The results documented were obtained for sensitivity with respect to distances, time and efficiency.

CHAPTER FOUR

RESULT AND DISCUSSION

4.1 RESULT

The result obtained from the testing of the toilet is presented in the Table 4.1

Distance (m)	**Response sensitivity**	**Toilet seat opening time (sec)**	**Toilet seat close time (sec)**	**Flush time (sec)**
0.2	Sensor activates	4.3	4.1	5
0.4	Sensor activates	4.1	4.	5
0.6	Sensor activates	4.2	4	5
0.8	Sensor activates	4.3	4	5
1	Sensor activates	4.3	4	5

Table 4.1 automated Toilet Operation Sensitivity

4.2 DISCUSSION

The system initiation was practically effective with all components in good working mode. From Table 4.1 it was observed that the power supply system was effectively functional. as the multi-meter reading indicated the flow of adequate supply voltage and current to the circuit. Form the results, it was observed that the toilet flush initiation was within an average time of 4.2 and 4 seconds respectively. Also the flush time was observed to be uniform across the number of test runs carried out. As long as there was water inside the reservoir, the water closet (WC) dispensed a given amount of water for flush of the toilet.

The Table 4.1 of results also show the sensitivity of the limit swich with respect to the presence of a user.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

Once a simple porcelain bowl, the modern toilet is now a high-tech throne. automated toilets automate old and dirty tasks, like flushing, for maximum efficiency. Now one can focus on enjoying a bathroom experience rather than worrying about the nitty gritty. The automated device allows users to customize their environment for optimal comfort. So irrespective of the weather conditions or space texture, automated toilets have got your back can be designed to be adaptive. The automated toilet developed in this project was deployed at the mechanical engineering department for operational use. The system performed according its design metrics.

The result from the experimental procedure showed that the system is suitable for use in homes, offices and public entities. The aim of the project which was to develop an automated toilet was achieved. The objectives of the project which includes the conceptualization, materials selection, installation and testing of the system were also achieved.

5.2 RECOMMENDATIONS

On conclusion of this research, the following recommendations were made:

i. To improve the efficiency of the automated toilet system, more sensitive sensors like ultrasonic sensors can be explored.
ii. The toilet can further be improved with the use of even lesser amount of water with the addition of a high power suction or push pump.
iii. The portability of the automated toilet system can be improved with smaller fixtures such as smaller shanks, smaller water reservoir etc.

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