Design of Odour Trap for Waterless Urinal System

Ms. Pranjali Laxman Bidwai

Abstract— Billions of gallons of water are used annually to flush toilets in the India. Consequences of this usage include consumption of natural resources and construction of new infrastructure to treat and transmit potable water and wastewater. Waterless, or no-flush urinals, may help mitigate these effects and offer other advantages, including lower utility charges, improved restroom hygiene, and decreased fixture maintenance. Waterless Urinals can be promoted at homes, institutions and public places to save water, energy and to harvest urine as a resource. As urine is about 96% liquid, no additional water is really needed to wash it down the drain. The waterless, urinal, looking much like its conventional counterpart, takes advantage of this concept with generally positive results. Odour trap mechanisms fitted to waterless urinals assist in preventing odour developed inside the drainage lines connected to the urinals from entering rest rooms. In this paper, the design of an effective odour trap, the maintenance of urinal and the use of urine as a fertilizer is depicted.

Index Terms— Crystal Oscillator, Electronic Control Unit, Hydrophobic material, Microcontroller, Odourless, Urinal System, Waterless urinal

1 Introduction

Waterless urinals are a promising step towards achieving water saving, more sustainable sanitation and reduced dependency on costly artificial fertilisers, thus contributing to poverty reduction. A urinal is a specialized toilet for urinating only, which is used while standing up, and is designed for male users. Urinals are widely used around the world, primarily in public facilities being frequented by a large number of people, because they save space and costs compared to toilets (simpler design; no separate cubicles needed, although in many cases separation panels are installed). Urinals are not commonly used in private households due to their additional space requirements. Some urinals for females (to be used while standing up, rather than squatting) are also on the market but they are not so popular for various reasons, e.g. females have greater need for privacy as they have to partially undress. Squatting type urinals (i.e. squatting pans with a small hole for urine but no hole for faeces) are sometimes used for girls in e.g. African or Asian primary schools to save on space and costs compared to toilets. Waterless urinals look very much like conventional urinals in design and these can be used in the same manner. However, waterless urinals do not require water for flushing and thus result in saving anything between 56,800 litres to 1,70,000 litres of water per urinal per year. On an average, a person urinates about four to five times a day. Urine, which is usually sterile and contains mostly water, does not require additional water for flushing to make it flow into drainage lines. Conventional urinals are flushed with approx. 4 L of water either after each use or based on a timer, whereas waterless urinals use no water for flushing. To guarantee a success, waterless urinals must meet the accepted standards applicable for conventional waterborne installations. Their odour emission must be less or at worst equal to the old system. Flushing with water is employed to control odour in the conventional urinals whereas waterless urinals utilise odour control mechanisms.Fig.1.1 shows the difference in water flash urinals and waterless urinals. Waterless urinals require regular cleaning routines similar to conventional urinals based on the number of users. Odour trap mechanisms fitted to waterless urinals assist in preventing odour developed inside the drainage lines connected to urinals from entering rest rooms.

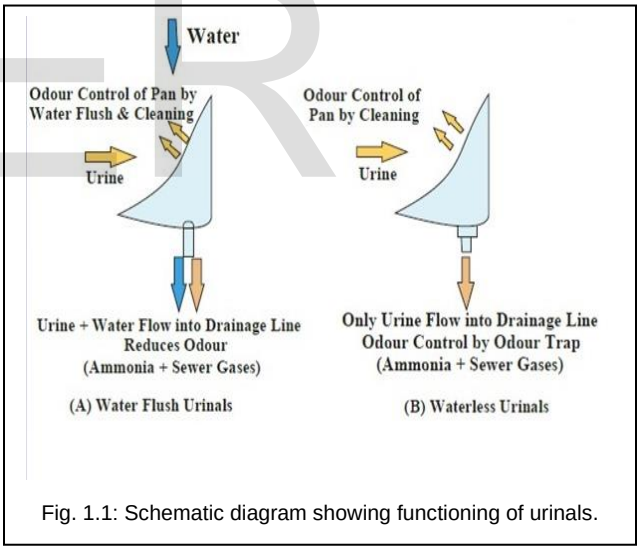

Fig. 1.1: Schematic diagram showing functioning of urinals.

2 Literature Survey

2.1 Waterless Urinals: Definition and Purpose

A urinal is a specialised toilet for urinating only, which is used while standing up, and is designed for male users. Urinals are widely used around the world, primarily in public. facilities being frequented by a large number of people, because they save space and costs compared to toilets (simpler design; no separate cubicles needed, although in many cases separation panels are installed). Urinals are not commonly used in private households due to their additional space requirements.

A limited number of urinals for females (to be used while standing up, rather than squatting) are on the market but they are not generally accepted for various reasons, e.g. females have greater need for privacy as they have to partially un-

dress. Squatting-type urinals (i.e. squatting pans without an outlet for faeces) are sometimes used for girls in e.g. African or Asian primary schools to save on space and costs compared to toilets.

Conventional urinals are flushed with approx. 4 L of water either after each use or based on a timer, whereas waterless urinals use no water for flushing. The main motivation for using waterless urinals (example shown in Figure 1) is to:

1. Save water (and energy) and hence costs – these urinals are simply connected to the sewer system.
2. Allow collection of pure, undiluted urine for use in agriculture as a nitrogen and phosphorus rich fertiliser – these urinals are connected to a urine storage tank.

2.2 Principle of Odour Control

To guarantee the success, waterless urinals must meet the accepted standards applicable for conventional waterborne installations. Their odour emission must be less or at worst equal to the old system. To achieve this odour-free performance four aspects are absolutely crucial for waterless urinals:

1. Suitable mechanism to block the odour coming back from the sewer or urine storage tank, for example (discussed in detail in the sections below):
   - rubber tube seal
   - curtain valve seal
   - sealant liquid (blocking fluid)
   - old light bulb or plastic table tennis ball placed in a funnel which is inserted in the opening of a jerrican
   - place urinal in a well-ventilated area (located outside of houses), and put up with some odour (may be possible for rural areas).
2. Appropriate surface of the urinal bowl (smooth, non-stick, e.g. with wax coating)
3. Correctly designed interrelation between urinal bowl and the drain fitting to minimize crevices where urine can accumulate.
4. On operational level: A thorough maintenance regarding the bowl and the odour blocking device. The surface of the urinal bowl is usually wiped clean once, twice or several times per day with a moist sponge. For the odour blocking device, the maintenance depends on the specifications by the urinal supplier.

2.3 DEFINITION OF ODOUR TRAP

A device which admits the urine flow through the urinal only when the urine enters the urinal, and maintains an air tight seal during the rest of the times, which results in a no contact of the atmospheric air and the urine collected below. Due to this, there is formation of ammonia and hence the odour is trapped. There are various odour trap and the Table 1 explains the Comparative Analysis of Popular Odour Traps

2.4 Type of Odour Traps

2.4.1 Spring ball odour trap

The odour trap arrangement consists of trap forming device such as tennis ball, air filled balloon or oil-filled balloon provided to a given urinal and to which elastic bands are extended and tied. The oil to be used in the balloon must have its specific gravity less than that of water. Such oils as paraffin can be used for the purpose. Vegetable oils will precipitate out and are, therefore, not suitable for forming floating devices. The trap forming devices are press tightened into position using the elastic band extension so that they form an effective odour trap. Upon usage of the urinal, the weight of the urine creates either an upward buoyant force or a down ward force of gravity that will lift or push down the trapping device and thereby allow urine to pass through the urinal. Fig 2.1 shows the mechanism of spring ball odour trap.

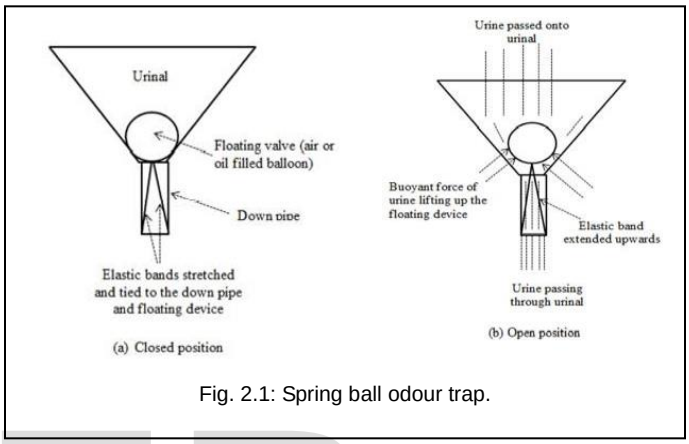

Fig. 2.1: Spring ball odour trap.

2.4.2 Sealant liquid trap

Odour traps using sealant liquids made of vegetable oils or aliphatic alcohols are fitted to urinal bowls to prevents odours from reaching the washroom. As sealant liquids have lower specific gravity than urine, these allow passage of urine but prevent odour emitted by drainage lines. The sealant liquid is contained either within a replaceable or built in cartridges provided to the urinal pans. Fig 2.2 shows the sealant liquid trap.

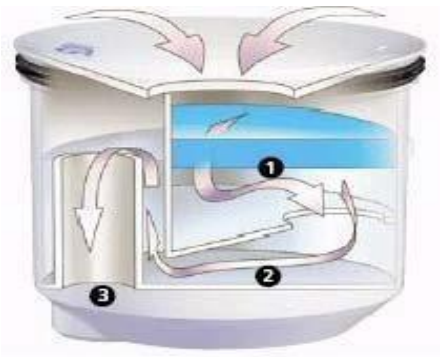

Fig 2.2: Sealant liquid trap.

2.4.3 Membrane traps

Membrane based traps use rubber, silicone or LDPE in the shape of tubes is used for controlling odour. The membrane acts as one-way valve allowing urine to flow while blocking odour released from drainage lines. The top portion of the tube is fixed to a holder to keep its mouth open. Rest of the portion deforms into a flat tube due to its flexibility and pre-

vents odour when urinal is not in use. A design variation of membrane-based trap is one in which, silicone tubes having their bottom portion split into two curtains have been introduced to reduce the requirement of frequent maintenance and to enable ease of cleaning. Urine with grit up to 2 mm is allowed to pass through. The picture of membrane trap is shown in fig. 2.3.

Fig. 2.3.: Membrane Trap.

2.4.4 Biological blocks

Biological blocks as shown in fig. 2.4 used for making urinals into waterless contain a number of active ingredients, including microbial spores and surfactants. These blocks are placed either in the urinal pans or housed within a dome inserted into the urinal waste outlet to gain contact with the urine flow. Upon interaction of urine with the block, the spores become active 'good' bacteria that 'feed' upon the urine and then multiply. By breaking down the urine into components, the build-up of sludge and crystals which because blockages are prevented. They also generate an environment hostile to odour causing bacteria. A busy urinal seat requires replacement of blocks which cost INR 20 each at an interval of 2-3 days.

Fig. 2.4.: Biological blocks

TABLE 1
COMPARATIVE ANALYSIS OF POPULAR ODOUR TRAPS

Description	Membrane Traps	Sealant Liquid	Biological Blocks
Odour Control	Good	Good	Good
Cost of the system	Trap can be fitted to existing urinal pans costing around Rs.500 1750/-. Cost of a trap is Rs.1200/-	New Urinal Pan with cartridge has to be procured. A single urinal Costs Rs.6,50014,000	Any urinal can be made Waterless using bio blocks. A bio block costs Rs.20/- (Lasts for 2-3 days depending on no. of users)
Retrofitting of Existing Urinals	Traps can be fitted to existing urinals	New sealant liquid based urinal pans to be installed	Bio-blocks can be placed in existing urinal pans
Replacement of Parts	Membrane needs to be replaced once in a year.	Sealant Liquid (approx. 1000 uses) & cartridge replacement (approx. once in a year).	Bio-blocks need to be replaced once 2-3 days based on usage.
Clogging Frequency	High (Silicon curtain valves require low maintenance)	Medium	Low
Maintenance of Pan & Trap	High	Medium	Low (only pan)
Flow of Particles through Trap	< 2mm size particles	Particles accumulate in trap cartridge	Same as in normal urinals

3 SYSTEM ANALYSIS

Fig 3.1 describes the Block Diagram of System and Fig 3.2 illustrates the 3D model design of System

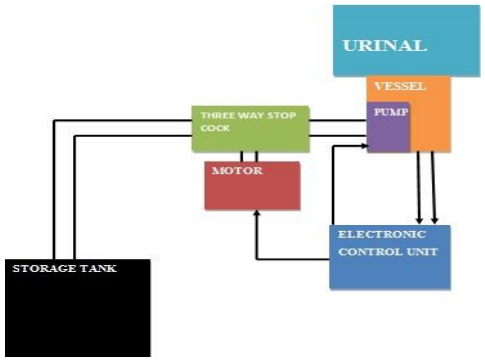

Fig. 3.1.: Block diagram of system.

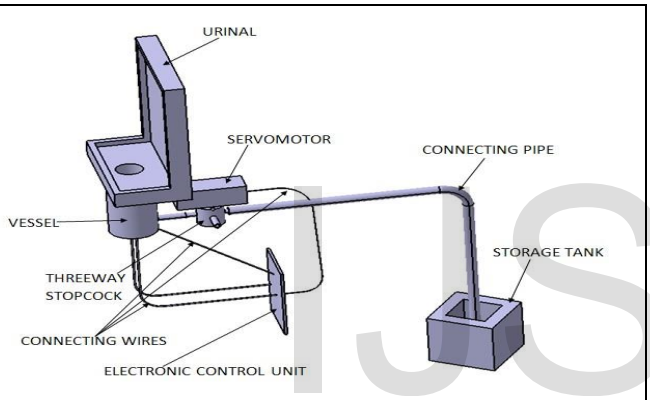

Fig. 3.2.: 3D diagram of system.

3.1 Urinals

The material of urinal is ceramic because of its properties like durability and cost. It is not necessary to use this type of urinal. There are various sizes and shapes of urinal are available in the market. We can use any one of it, for example Fig 3.3.

Fig. 3.3.: Urinal

3.2 Hydrophobic Coating

Hydrophobicity is the physical property of a molecule that is seemingly repelled from the mass of water. Hydrophobic coating is a surface layer that repels water. Droplets hitting this kind of coating can fully rebound in the shape of a column. There is no repulsive force involved; it is an absence of attraction. In contrast, hydrophiles are attracted to water.

In our system I have applied hydrophobic coating on urinal as urine contains 95% water and hence it is also repelled by the hydrophobic coating. I have used RUST-OLEUM Neverwet MULTI-SURFACE LIQUID REPELLING TREATMENT. It is an advanced water proofing treatment. It is super hydrophobic coating that dramatically repels water, mud, ice and other liquids. This revolutionary new class of coating cause water to form nearly perfect spheres, which roll of the surface keeping items dry and clean. It is two step water repelling spray paint system designed to create a moisture repelling barrier on a variety of surface. It is suitable for use on metal, wood, aluminium, galvanized metal, PVC, concrete masonry, asphalt, vinyl siding, fibre glass, canvas, most plastics and more. One kit covers 10-15 square feet.

Step 1: Spray on the Neverwet Base Coat and allow to dry for 30 minutes before applying the Neverwet Top Coat.

Step 2: Spray on several light coats of the Neverwet Top Coats of the Neverwet Top Coat. Wait at least 30 minutes before exposing to liquid.

3.3 Odour Trap

Odour trap consists of following components:

3.3.1 Collecting Vessel

A plastic vessel of is used for collecting the urine. It is connected to the outlet of urinal. It also holds the pump in place which further pumps out the urine.

3.3.2 Submersible Pump

Micro DC 3-6V Micro Submersible Pump Mini water pump For Fountain Garden Mini water circulation System DIY project as shown in Fig 3.4. This is a low cost, small size Submersible Pump Motor which can be operated from a 3 ~ 6V power supply. It can take up to 120 litres per hour with very low current consumption of 220mA. Just connect tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise.

Specification:

- Operating Voltage: 3~6 V
- Operating Current: 130~220 mA
- Flow Rate: 80~120 L/H
- Maximum Lift:40~110 mm
- Continuous Working Life: 500 hours
- Driving Mode: DC, Magnetic Driving
- Material: Engineering Plastic
- Outlet Outside Diameter: 7.5 mm
- Outlet Inside Diameter: 5mm

Fig. 3.4.: Submersible pump

3.3.3 Three Way Stopcock

It provides 3-way flow (from inlet to outlet, inlet to side-port or side port to outlet) by use of the handle on the top of the stopcock to open and close lines. I used it for one directional flow of urine and to restrict the backflow of odour from storage tank as shown in Fig 3.5. Odour is trapped by maintaining the air tight position when stopcock is closed. I have blocked one way of the stopcock and of the remaining two, one way is connected to the outlet of pump and other is connected to the inlet of the storage tank. It is actuated by servomotor.

Fig. 3.5.: Three Way Stopcock.

3.3.4 Activated Charcoal

Activated carbon, also called activated charcoal, is a form of carbon processed to have small, low-volume pores that increase the surface area available for adsorption or chemical reactions. Activated is sometimes substituted with active.

Activated is usually derived from charcoal and is sometimes used as biochar. When derived from coal or corn it is referred to as activated coal. Activated coke is derived from coke. Activated charcoal works by trapping toxins and chemicals in the gut, preventing their absorption. The charcoal's porous texture has a negative electrical charge, which causes it to attract positively charged molecules, such as toxins and gases. This helps it trap toxins and chemicals in the gut.

I have used activated carbon pellets which are used in fish tanks. It removes odour and also absorbs the odour in case there is some amount of urine left in the collecting vessel. I have provided a layer of activated charcoal pellets in the vessel with the help of strainer.

3.3.5 Electronic Control Unit

3.3.5.1 Input Devices (Probes)

There are two probes, one probe is connected to power supply and the other probe is connected to microcontroller. The probes work on the principle that, when there is infinite resistance between the probes, no current flows between them. When the resistance between the probes is finite, the current flows between them and the signal is sent to the microcontroller in the form of input signal. The probes are connected from the base of the vessel and certain gap is maintained between them.

3.3.5.2 Output Devices

a. LCD Display

LCD display is used to display the number of times the urinal is used by counting the number of times the stopcock is opened. A 16x2 alphanumeric dot matrix display is used for this purpose. Fig. 3.6 shows LCD Display.

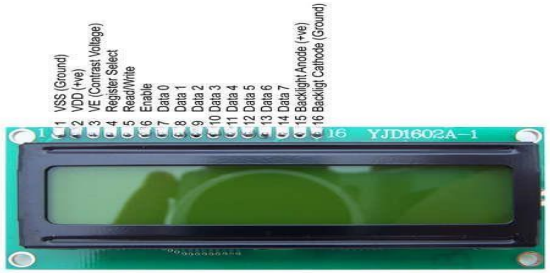

Fig. 3.6.: LCD Display.

b. Servo Motor

I have used servo motor for opening and closing of 3-way stopcock. Servo motor is tiny and lightweight with high output power. This servo can rotate approximately 180 degrees (90 in each direction), and works just like the standard kinds but smaller. You can use any servo code like Fig 3.7, hardware or library to control these servos. It comes with a 3 horns (arms) and hardware.

Fig. 3.7.: Servo motor

c. Submersible Pump

Micro DC 3-6V Micro Submersible Pump Mini water pump For Fountain Garden Mini water circulation System DIY project. This is a low cost, small size Submersible Pump Motor which can be operated from a 3 ~ 6V power supply. It can take up to 120 litres per hour with very low current consumption of 220mA. Just connect tube pipe to the motor outlet, submerge it in water and power it. Make sure that the water level is always higher than the motor. Dry run may damage the motor due to heating and it will also produce noise. Fig 3.8 shows Submersible pump.

Fig. 3.8.: Submersible Pump

3.3.5.3 Microcontroller

This project consists of ATMmega 328p microcontroller, which receives input from the probes, receives programmed commands in the form of clock pulses from the crystal oscillator and gives one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers. The output signal to the LCD display, servo motor and the pump.

The ATMmega328P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. By executing powerful instructions in a single clock cycle, the ATmega328P achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed. The AVR core combines a rich instruction set with 32 general purpose working registers. All the 32 registers are directly connected to the Arithmetic Logic Unit (ALU), allowing two independent registers to be accessed in one single instruction executed in one clock cycle. The resulting architecture is more code efficient while achieving throughputs up to ten times faster than conventional CISC microcontrollers. The Pin Diagram of Microcontroller is described in Fig.3.9.

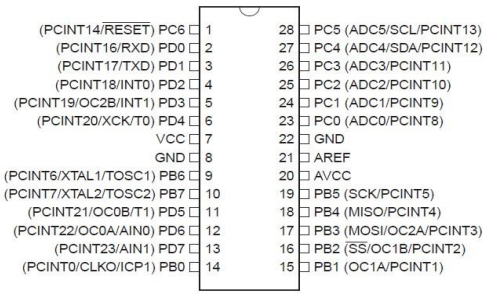

Fig. 3.9.: Pin diagram of microcontroller

VCC: Digital supply voltage.

GND: Ground.

Port B (PB7:0) XTAL1/XTAL2/TOSC1/TOSC2:

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Depending on the clock selection fuse settings, PB6 can be used as input to the inverting. Oscillator amplifier and input to the internal clock operating circuit. Depending on the clock selection fuse settings, PB7 can be used as output from the inverting Oscillator amplifier.

Port C (PC5:0):

Port C is a 7-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The PC5...0 output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active even if the clock is not running.

PC6/RESET:

If the RSTDISBL Fuse is programmed, PC6 is used as an I/O pin. Note that the electrical characteristics of PC6 differ from those of the other pins of Port C. If the RSTDISBL Fuse is unprogrammed, PC6 is used as a Reset input. A low level on this pin for longer than the minimum pulse length will generate a Reset, even if the clock is not running.

Port D (PD7:0):

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running.

AVCC:

AVCC is the supply voltage pin for the A/D Converter, PC3:0, and ADC7:6. It should be externally connected to VCC, even if the ADC is not used. If the ADC is used, it should be connected to VCC through a low-pass filter. Note that PC6...4 use digital supply voltage, VCC.

AREF:

AREF is the analogy reference pin for the A/D Converter.

ADC7:6 (TQFP and QFN/MLF Package Only):

In the TQFP and QFN/MLF package, ADC7:6 serve as analog inputs to the A/D converter. These pins are powered from the analog supply and serve as 10-bit ADC channels the three essential components of microcontroller are:

a. Power supply

The components of power supply are input connector, diode, capacitor and 7805 regulators. The input is from the mains supply through a 12V adapter. The adapter converts 220V AC to 12V DC. The adapter end pin is connected to input connector on the electronic circuit. The diode and capacitor form a filter circuit. The 7805 regulator is used to step down the 12 V to 5V as the microcontroller needs 5V. A separate divider circuit and a 9V battery is used to supply power to the pump as pump need more current compared to servo motor in which

less current is needed due to Pulse Width Modulation(PWD). The divider circuit boosts the current. Specifications of the component used are as follows:

i) Diode

A PN-junction diode is formed when a p-type semiconductor is fused to a type semiconductor creating a potential barrier voltage across the diode junction. Semiconductors contain two types of mobile charge carriers, "Holes" and "Electrons". The holes are positively charged while the electrons negatively charged. A semiconductor may be doped with donor impurities such as Antimony (N-type doping), so that it contains mobile charges which are primarily electrons. A semiconductor may be doped with acceptor impurities such as Boron (P-type doping), so that it contains mobile charges which are mainly holes. The junction region itself has no charge carriers and is known as the depletion region. The junction (depletion) region has a physical thickness that varies with the applied voltage. When a junction diode is forward biased the thickness of the depletion region reduces and the diode acts like a short circuit allowing full current to flow. I have used forward bias PN-junction diode as shown in Fig 3.10.

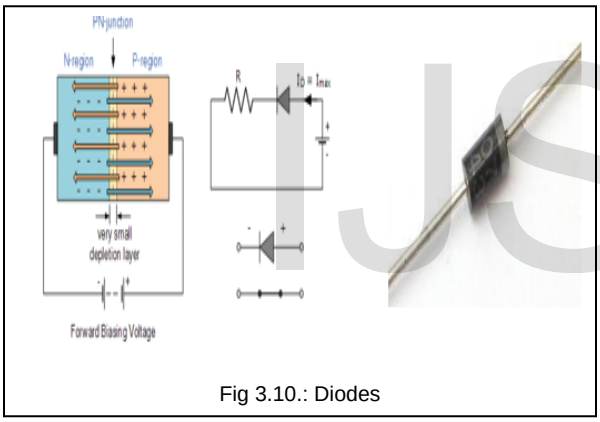

Fig 3.10.: Diodes

ii) Capacitor

The properties of capacitors in a circuit may determine the resonant frequency and quality factor of a resonant circuit, power dissipation and operating frequency in a digital logic circuit, energy capacity in a high-power system, and many other important aspects. Fig 3.11 shows the various types of capacitor.

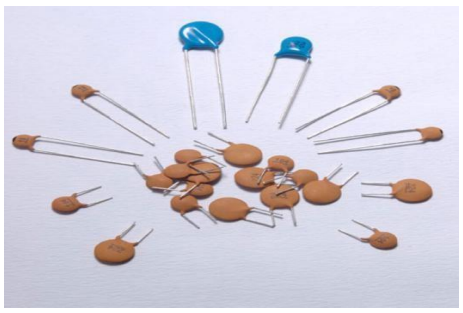

Fig 3.11.: Capacitor

iii) 7805 IC Regulator

Voltage sources in a circuit may have fluctuations resulting in not providing fixed voltage outputs. A voltage regulator IC maintains the output voltage at a constant value. 7805 IC, a member of 78xx series of fixed linear voltage regulators used to maintain such fluctuations, is a popular voltage regulator integrated circuit (IC). Table 2 gives information of pin for 7805 IC Regulator as shown in Fig.3.12

TABLE 2
7805 IC REGULATOR PIN DESCRIPTION

Pin Number	Pin name	Description
1 to 7	Input 1 to Input 7	Seven Input pins of Darlington pair, each pin is connected to the base of the transistor and can be triggered by using +5V
8	Ground	Ground Reference Voltage 0V
9	COM	Used as test pin or Voltage suppresser pin (optional to use)
10 to 16	Output 1 to Output 7	Respective outputs of seven input pins. Each output pin will be connected to ground only when its respective input pin is high(+5V)

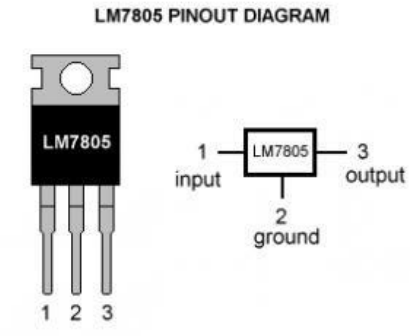

Fig 3.12.: 7805 IC Regulator

iv) ULN2003 Divider IC

This IC (Fig. 3.13) is used to boost the current and sup-

ply it to the pump with the help of 9V battery.

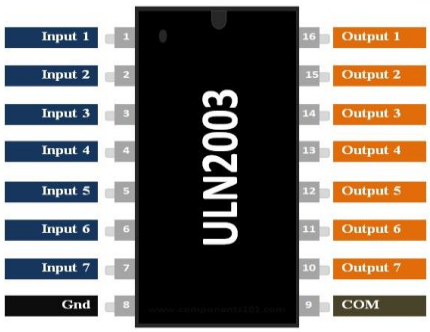

Fig 3.13.: ULN2003 Divider IC

b. Clock circuit

An electronic oscillator is an electronic circuit that produces a repetitive electronic signal, often a sine wave or a square wave.

Crystal oscillator

A crystal oscillator is a circuit that uses a piezoelectric crystal (commonly a quartz signal) as a frequency selective element. The crystal mechanically Fig.3.14 Crystal Oscillator vibrates as a resonator, and its frequency of oscillation oscillator determines the oscillation frequency. They are used to stabilize the frequency of radio transmitters and to generate the clock signal in computers and quartz clocks.

Fig 3.14.: Crystal oscillator

3.3.5.3 Working of Electronic Control Unit

The input is from the mains supply through a 12V adapter. The adapter converts 220V AC to 12V DC. The adapter end pin is connected to input connector on the electronic circuit. The diode and capacitor form a filter circuit. The 7805 regulator is used to step down the 12 V to 5V as the microcontroller needs 5V. When the urine is collected in the vessel, the resistance between the probes decreases. Thus, the probes give input signal to the microcontroller. The microcontroller receives programmed commands in the form of clock pulses from the crystal oscillator and gives one clock cycle. The output signal from the microcontroller goes to LCD screen, servo motor and pump. A separate divider circuit and a 9V battery is used to supply power to the pump as pump need more current compared to servo motor in which less current is needed due to Pulse Width Modulation (PWD). As soon as the output signal is received, the LCD screen displays the count and the servomotor opens the 3-way stop cock by rotating it through 90^0. As programmed in the microcontroller it sends output signal to the pump after 1 second and then the pump starts. The urine is pumped out through the 3-way stop cock and is collected in storage tank. When all the urine is pumped out from the vessel, the resistance between the probes is infinite and thus there is no input to the controller. As programmed, the pump stops after one second and after another 1 second the servomotor reverses its direction through 90^0 and the 3-way stop cock is closed thus stopping the reverse flow of air from storage tank to the urinal. In this way the odour is trapped. Fig. 3.15 gives idea about circuit diagram of electronic control unit used in this project.

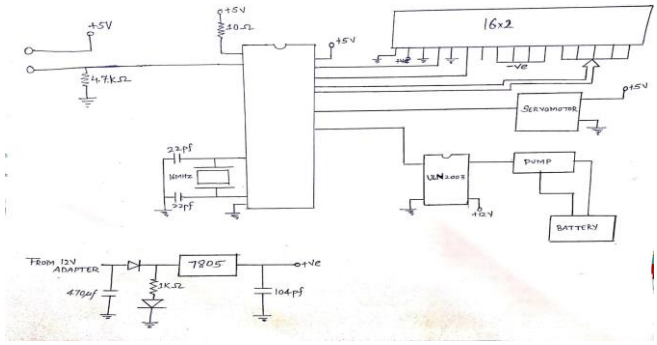

Fig 3.15.: Circuit diagram of electronic control unit

3.4 Working of the System

- The urinal is coated with hydrophobic material using the spray.
- The vessel is connected to urinal end in which the urine is collected. The vessel consists a layer of activated charcoal pellets on the upper side of the vessel. These pellets are placed on the strainer.
- The pump is placed in the vessel and the probes are inserted from the vessel base maintaining some gap between the two.
- The pump outlet is connected to the 3 way stop cock by using the pipes. The valve of 3 way stop cock is actuated by the servo motor connected to it.
- The outlet of 3 way stop cock is connected to the storage tank placed below the urinal by using the pipe.
- When the person urinates, due to the hydrophobic coating, the urine forms zero contact angle with the urinal surface. Due to this, a non-sticky contact is formed between the urine and the surface.
- As the urine enters the vessel, it first passes through the layer of charcoal pellets and is strained by the strainer. Hence most of the odour is adsorbed on the charcoal.
- The urine is then collected in the vessel. Due to the presence of urine, the resistance between the probes becomes zero. As one probe is connected to the power supply and other probe is connected to the controller, the probe gives input signal to the controller.
- The pulse signals are generated in the controller and the output signals produced are given to the servo motor and the pump.
- The servomotor opens the 3 way stop cock and after 1 second, the pump is switched ON.

- Thus, the urine is pumped out through the 3-way cock and goes to the storage tank via interconnected pipes.
- The count of opening of the valve is displayed on the LCD screen.
- After all the urine is pumped out, there exists some resistance between the probes and the input signal no longer flows to the controller. Thus, the pump is stopped, and after one second the stop cock is also closed using the servomotor.
- Due to the closed position of the stopcock in the non-working conditions the odour does not flow back to the urinal and hence the odour is trapped. Also, if some amount of urine is left in the vessel, the odour is adsorbed by the charcoal pellets.

4 Application

- For industrial purpose.
- For commercial complexes, malls, airport, restaurants and hotels.

Urine can be used for agricultural and industrial purposes using the following methods:

Direct Application

- Urine can be directly applied to agricultural lands during land preparation and to fertilise crops after plantation.
- Urine must be applied to soil around the plants by creating furrows. The furrows should be covered with soil after application of urine to prevent loss of nitrogen through ammonia gas.
- Use of watering cans which are commonly used in home gardens can be ideal for application of urine.

Deep Injection

- Deep injection of urine up to 6 inches below the ground surface considerably reduces the ammonia loss. This method is more suited for horticultural plantations where plant density is lower than the traditional crops in a given area.
- Using subsoil injectors and pot irrigation method (use of PET bottles having small holes at bottom can be handy) deep injection of urine can be achieved at low cost.
- For large scale application, custom made mechanised agricultural tools can be designed for deep injection of urine.

Drip Irrigation

- Urine applied along with irrigation water and applied through drip irrigation.
- Fertilisation tank filled with urine to be applied to crops is connected to water mains carrying water for drip irrigation.
- Regular maintenance of emitters and tubes is necessary to prevent clogging.

Struvite

- Struvite is a fertiliser in solid for containing magnesium ammonium phosphate and is obtained by adding magnesium chloride to urine.
- This process is carried out after pH of urine stored in a closed container increases substantially over time. Addition of magnesium and slow stirring for 10 minutes leads to precipitation of struvite which can be filtered and used as fertiliser.

5 Maintenance

Undertaking proper maintenance routines of waterless urinals installed is essential for ensuring their effective functioning. Improper maintenance of the waterless urinals may result in failure of this novel concept. Therefore, sensitising the users, training of maintenance staff and allocation of adequate budget for meeting the maintenance requirements must be ensured after installation of waterless urinals.

The following steps should be considered while installing waterless urinals:

Waterless Urinal System

- An appropriate type of waterless urinal odour trap can be chosen based on the location to be installed, investment cost, maintenance costs and easy availability of spares.
- Maintenance instructions of the manufacturer to optimise the performance of the odour traps must be followed.
- Cleaning staff must wear gloves and face masks while attending maintenance works.
- Users of urinal must be educated to avoid spitting and throwing of cigarette butts and chewing gum in the urinal pans.

Drainage Pipes and Fittings

- There should be no sharp 90° bends in the pipes carrying urine to prevent accumulation of deposits.
- Pipes carrying urine should be at least 2 in in diameter (except the connector lines below the urinal pans) and they must be laid with a slope of at least 1:100.
- Pipes carrying urine can be of polyethylene (PE) or polyvinyl chloride (PVC).
- Length of urine pipes should be short to prevent clogging. Flushing of pipes can be taken up based on the clogging of pipes.
- No vent pipe should be provided to prevent loss of nitrogen in the form of ammonia gas. If necessary, a one-way air admittance valve be provided to equalise gas pressure in the pipeline.
- Loose and open connections in the urine pipes and urinal pans must be avoided to prevent release of odour.

Storage of Urine and Pumping

- Storage tanks made of plastic materials, inflatable rubber and high-quality masonry can be used when reuse of urine is intended. These can be over ground or below ground, but adequate precautions for structural safety must be followed.
- The urine inlet pipe to the tank can be up to floor level of the storage tank to prevent turbulence in the tank.
- For large storage tanks, pumps which can handle some amount of precipitates in the tank must be chosen. For small storages, small submersible pumps used in household air coolers can be used.

6 Conclusion

Waterless urinals are urinals which use no water for flushing, and are designed to emit the same or lower odour compared to conventional water flushed urinals. The main motivation for using waterless urinals is to save water (urinals connected to a sewer system) and/or to collect urine for the purpose of using the urine's nitrogen and phosphorus as fertilizer in agriculture (urinals connected to a urine storage tank). This would reduce the dependency of small scale. African farmers on costly artificial fertilizers and hence contribute to poverty reduction.

Odour control in waterless urinals is crucial for user acceptance, and is achieved by (i) various designs available for an odour blocking mechanism (ii) by ensuring correct maintenance procedures. In cases where maintenance routines are expected to be neglected, low maintenance waterless urinals should be selected.

The use of electronic control unit in the odour trap makes the trap more accurate, efficient, sensitive compared to mechanical odour traps. Also, the life and maintenance of the electronic components is better than mechanical components. Waterless urinals are need of today's and upcoming generation.

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