

Smart Floor Cleaning Robot (CLEAR)

Uman Khalid¹, Muhammad Faizan Baloch¹, Haseeb Haider¹, Muhammad Usman Sardar¹,
Muhammad Faisal Khan^{1,2}, Abdul Basit Zia¹ and Tahseen Amin Khan Qasuria¹

¹Faculty of Electronic Engineering, Ghulam Ishaq Khan Institute of Engineering Sciences and Technology, Pakistan

²Hamdard Institute of Engineering & Technology, Hamdard University, Karachi, Pakistan

umankhalid@gmail.com, u2011237@giki.edu.pk, u2011129@giki.edu.pk, u2011311@giki.edu.pk
mfaisalkhan1@gmail.com, abzgiki@gmail.com, qasuria@giki.edu.pk

Abstract—With the advancement of technology, robots are getting more attention of researchers to make life of mankind comfortable. This paper presents the design, development and fabrication of prototype Smart Floor Cleaning Robot (CLEAR) using IEEE Standard 1621 (IEEE Standard for User Interface Elements in Power Control of Electronic Devices employed in Office/Consumer Environments). Subject robot operates in autonomous mode as well as in manual mode along with additional features like scheduling for specific time and bagless dirt container with auto-dirt disposal mechanism. This work can be very useful in improving life style of mankind.

Index Terms—Autonomous roaming, manual control, power status indications, power controls, power efficient, cleaning robot.

I. INTRODUCTION

In recent years, robotic cleaners have taken major attention in robotics research due to their effectiveness in assisting humans in floor cleaning applications at homes, hotels, restaurants, offices, hospitals, workshops, warehouses and universities etc. Basically, robotic cleaners are distinguished on their cleaning expertise like floor mopping, dry vacuum cleaning etc. Some products are based on simple obstacle avoidance using infrared sensors while some utilize laser mapping technique. Each cleaning and operating mechanism of robotic floor cleaners has its own advantages and disadvantages. For example, robots utilizing laser mapping are relatively faster, less time consuming and energy efficient but costly, while obstacle avoidance based robots are relatively time consuming and less energy efficient due to random cleaning but less costly. Countries like Pakistan are way back in manufacturing robotic cleaners. Importing them from abroad increases their costs. The main objective of this work is to provide a substantial solution to the problem of manufacturing robotic cleaner utilizing local resources while keeping it low costs.

In this work, “smart floor cleaning robot (CLEAR)” has been designed for consumer/office environments and its each component in accordance with IEEE Standard is discussed. Proposed design is being operated in dual modes. In one of the modes, the robot is fully autonomous and making decisions on the basis of the outputs of infrared proximity sensors, ultrasonic sensors and tactile sensors after being processed by Arduino (mega) controller and control the actuators (2 DC encoder motors) by the H-bridge driving circuitry. In manual mode, the robot can also be used to clean a specific area of a room by controlling it manually from laptop with a Graphical User Interface (GUI) in Visual Studio (C# programming language) via Bluetooth connectivity.

This paper is arranged in eight sections. IEEE standard used in this project is discussed in Section II. A detailed literature review of robotic vacuum cleaners is presented in Section III. Section IV covers

the mechanical design of robot including chassis design, brushing, vacuum cleaning mechanism and auto-dirt disposal mechanism. Electronic circuitry (including motor controllers, vacuum cleaner controller, battery status meters and brushing motor controller along with safety circuit for power supply to sensors, arduino controller as well as precautionary circuit) is discussed in Section V. Graphical User Interface (GUI) of the project and robot operation are discussed in Section VI and VII respectively. All these sections describe their relevance to the application of IEEE Standard 1621. Conclusions of the project are summarized in Section VIII.

II. STANDARD APPLIED

The standard being applied is IEEE Std 1621™-2004(R2009) “IEEE Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments” for the design and fabrication of “Smart Floor Cleaning Robot”. IEEE Standard 1621 enabled authors to learn and implement basic power & control mechanism for subject robot, thus making it user friendly. The mode of implementation of IEEE Standard 1621 is discussed in detail in later sections.

III. LITERATURE REVIEW

A robotic vacuum cleaner is an autonomous electronic device that is intelligently programmed to clean a specific area through a vacuum cleaning assembly. Some of the available products can brush around sharp edges and corners while others include a number of additional features such as wet mopping and UV sterilization rather than vacuuming. Some of the available products are discussed below.

A. *iRobot*[2]

In 2002, iRobot launched its first floor vacuum cleaner robot named Roomba. Initially, iRobot decided to manufacture limited number of units but Roomba immediately became a huge consumer sensation. Due to its increased market demand, a series of following robots have been launched in the market:

1. Roomba

- Launch Date: 2002
- Manufacturer: iRobot (American)
- Type of Use: Dry Vacuum
- Technology: IR, RF and auto-charging mechanism
- Price: \$500

2. Scooba

- Launch Date: 2005
- Manufacturer: iRobot (American)
- Type of Use: Wet Washing of Floor
- Technology: IR with virtual wall accessories
- Price: \$500

3. Braava

- Launch Date: 2006
- Manufacturer: iRobot, KITECH, Sony
- Type of Use: Floor mopping for hard surfaces/Dry clean
- Technology: IR with virtual wall accessories for industrial cleaning
- Price: \$700

B. NEATO Robotics[3]

With the advent of robotic vacuum cleaners, many countries had started manufacturing robotic cleaners. China also started manufacturing these robots with more reliable technology and advanced features.

1. Neato XV-11

- Launch Date: 2010
- Manufacturer: Neato-Robots XV series (California)/China
- Type of Use: Vacuum Cleaning
- Technology: Laser range finder technology, SLAM (Simultaneous localization and mapping) and auto-charging
- Price: \$399

C. Dyson[4]

In 2001, Dyson built a robot vacuum known as DC06 which was never released to the market due to its high price. In 2014, Dyson launched a new product named as Dyson 360 Eye which uses a different technology for path finding as compared to products manufactured by NEATO Robotics or iRobot.

1. EYE-360[5]

- Launch Date: 2016
- Manufacturer: Dyson (UK)
- Type of Use: Vacuum Cleaning
- Technology: It uses a 360 degree panoramic vision camera to monitor its environment in real time and a turbo brush for efficient cleaning along with an auto-charging mechanism (Benchmark in history of cleaning robots)
- Price: \$1000 (approx.)

A comparison of proposed robot CLEAR with the top selling robotic cleaners in international market on the basis of general specifications like operating time, charging time, scheduling, floor type, battery indicators and navigation features is summarized in Table I.

TABLE I. COMPARISON OF CLEAR WITH AVAILABLE PRODUCTS [6].

FEATURES	ROBOTS		
	NEATO -XV	ROOMBA	CLEAR
Operating time (hr)	1.5	2	1.2
Charging time (hr)	3	4	2
Scheduling	Yes	Yes	Yes
Battery indicators	Yes	Yes	Yes
Full-bin indicators	Yes	Yes	Yes
Remote control	Yes	Yes	Yes
Return to base	No	No	Yes

D. Comparison with previous Patented Devices

A detailed comparison of previous patented robotic vacuum cleaners with CLEAR on the basis of main features of control mechanism like automatic or manual mode and cleaning expertise like dry vacuum cleaning or mopping along with additional features like bag-less container etc. is summarized in Table II.

TABLE II. COMPARISON OF CLEAR WITH PATENTS.

PATENTS	SALIENT FEATURES	'CLEAR' FEATURES
Autonomous floor mopping apparatus ^[7] US-6,741,054	This robot is autonomous and can be remotely controlled.	Autonomous motion using IR sensor mechanism and manually controlled via GUI controls.
	A feed roller lets out a roll toweling, take-up roller reels in the toweling, and a motor system causes it to rotate while robot moves.	Simple roller brushing and vacuuming.
Autonomous floor-cleaning robot ^[8] US-6883201 B2	Self-adjusting cleaning head with brush assembly having counter-rotating, asymmetric brushes.	Simple roller brushing.
	Independent, vacuum assembly so that the cleaning capability and efficiency is optimized.	Separate vacuum assembly.
	A removable dust cartridge.	Dirt compartment with auto-disposal.
	A control system, in	Autonomous motion

	communication with the motive system having feedback from sensors.	using IR sensor mechanism and manually controlled via GUI controls.
Autonomous surface cleaning robot for wet and dry cleaning ^[9] US-7,389,156	The robot chassis carries cleaning elements to suck particles up from the cleaning surface and apply a cleaning fluid onto the surface to collect the cleaning fluid up from the surface using a rotating sponge.	A roller brush brooming the dirt into dirt compartment aided by a vacuum cleaner.
	The robot includes controls and drive elements configured to control the robot using sensor mechanism.	Autonomous motion using IR sensor mechanism and manually controlled via GUI controls.
	A removable dust cartridge with separate tank for cleaning fluid.	Dirt compartment with auto-disposal.
Cleaning Robot and control method thereof ^[10] US-2013/0231819	Contains a movement module, a sound wave sensor module, a cleaning module (vacuum only) and a controlling module.	Autonomous motion using IR sensor mechanism and manually controlled via GUI controls with brushing and vacuuming.
Autonomous surface cleaning robot for dry cleaning ^[11] US-8,782,848	Includes a transport drive and control system arranged for autonomous movement of the robot.	Autonomous motion using IR sensor mechanism and manually controlled via GUI controls.
	Vacuuming assembly and a waste container for storing waste.	Brushing and vacuuming assembly with a waste container capable of auto-disposing.
	Also includes wet cleaning separately.	Wet cleaning feature is not available.
System and method for autonomous mopping of a floor surface ^[12] US-8,892,251	Cleaning the surface with a cleaning pad and cleaning solvent.	Brushing and vacuuming with auto-disposal of waste.
	Movement of robot can be programmed by a class of trajectories that achieve effective cleaning. The trajectories include sequences of repeated steps like forward and backward motion with optional left and right motion in accurate paths.	Movement is controlled by IR sensor data using obstacle avoidance technique but can be programmed for calculated trajectories and orientations using a Magnetometer module.

IV. MECHANICAL DESIGN OF CLEAR



Figure 1. Mechanical Design of CLEAR.

Mechanical body consists of four parts i.e., chassis, brushing mechanism, vacuum cleaning and dirt disposal mechanism. Combination all these four parts makes a complete prototype for testing, as shown in Figure 1. Before fabrication, complete CAD Model was designed using a commercially available software.

A. Chassis

The base of the body comprises of acrylic sheet, two encoder motors along with Teflon tires having O-rings on them for avoiding friction, two ball casters of adjustable height having frictionless steel balls, aluminum angular brackets and aluminum holders for two lead acid batteries of 12V and 1.2Ah rating. These motors are independently powered and mounted diagonally and two ball casters are placed at other diagonal of acrylic sheet so that motors can move along its axis easily and bear more weight as compared to chain mechanism. Cleaning assembly includes a DC geared motor, sprockets for moving chain from geared motor to rotating brush and two aluminum rods for supporting vacuum cleaner mechanism and dirt compartment. This DC geared motor has been fitted on one side of acrylic sheet with aluminum holder and sprockets installed with it which have been fitted into shaft of motor. All components are installed on lower side of acrylic sheet so that center of gravity should be lower and robot would be stable.

B. Brushing

Brushing mechanism consists of one rolling brush, steel sheet for cover, two aluminum holders, two ball-bearing and one mild steel strip. One rolling brush mounted on aluminum holders with bearings inside them. This mechanism is attached through mild steel strip to the base of robot. Brush is used to broom the dirt particles into the vacuum chamber in case of carpeted floor for efficient cleaning.

C. Vacuum Cleaning and Dirt Disposal

Vacuum cleaning and dirt disposal mechanism consists of vacuum motor, propeller, steel holders for fixing motor, filter mounted on two steel rods, aluminum alloy sheet, steel sheet, servo motor, aluminum brackets and aluminum strips. Propeller mounted to a vacuum motor fixed by steel holders and filters are placed on inside of aluminum alloy. Steel sheet has been molded in such a shape that it gave a shape of a robot. Aluminum alloy is also molded into a shape just like steel sheet but of bigger size. Both sheets are attached together results in narrow tunnel from front side and broad compartment at back side. Narrow tunnel is necessary for better suction of dirt and broad compartment is used as dirt compartment. At very last end of

both sheets there is an aluminum strip controlled by servo motor installed at upside of aluminum alloy right behind vacuum cleaner to dispose of dirt. Vacuum Cleaner battery holder is spot welded on inner side to support 18.1V, 5AhLiPo battery.

V. ELECTRONIC CIRCUITRY

All circuits are first designed and simulated in Proteus software. After optimization of values for components, circuits were implemented on PCB. There are five main circuits including three batteries being used in this project and all these circuits are designed, analyzed and then implemented in accordance with IEEE Standard 1621. Explanation of all these circuits is given below:

A. Motor Controllers

Motor controllers commonly known as H-Bridge, are used for driving motors in both direction that is clockwise and counter-clockwise with current rating of 15 A. This controller consists of two parts. First part is to energize relays through Arduino controller and drive motors while second part is for controlling the speed of motors. Relays are used for switching purposes while transistors are used for speed control. Relays used in this circuit have rating of 12V dc coil and 15A current while lead acid battery of a 12V and 1.2Ah rating. Since encoder motors have a stall current of 7A so for safe purpose 15A relays have been used. Two diodes are implemented in fly back diode configuration. This is a condition in which a diode is put in reverse state between battery terminals and is commonly known as free-wheeling diode. At de-energizing of relay huge voltage is produced in backward state and can damaged other components so to avoid this damage a diode in fly back configuration is used along with relay. Pulse width modulation (PWM) is used for speed control. PWM is given to transistor BJT 2N2222 along with some duty cycle to compel motor to start at some intervals resulting in controlling speed. This circuit is powered up through separate battery connected through ON/ OFF switch and fuse to provide protection and a Red LED glowing if the circuit is Disconnected owing to section: 4 of IEEE Std. 1621.

B. Vacuum Cleaning Controller

The circuit used for controlling of vacuum cleaner consists of one transistor, one relay, one diode and two batteries. One Lead acid battery of 12V and 1.2Ah ratings is for power controlling (ON/OFF) of vacuum cleaner by energizing coil of relay having diode in a fly back position while one LIPO battery of 18V and 5Ah is for supplying power to vacuum cleaner with different ground terminals to avoid short circuit currents and properly isolate the batteries from circuit including a separate Yellow LED for Disconnected state owing to section: 4 of IEEE Std. 1621. Signal from Arduino controller is given to transistor BJT 2N2222 which energizes relay and relay switches. After switching, relay will allow 18V battery to supply power through it and turns on vacuum cleaner through an ON/OFF switch. This circuit is properly insulated to provide safety since currents may exceed to 7A.

C. Battery Meters

This circuit consists of two buffer ICs, six colored LED's (3-Red & 3-Green) indicating battery power status and four resistors for voltage divider. Positive terminal of circuit battery is connected to one resistor and output taken from second resistor gives a fixed voltage that fixed voltage goes to buffer IC so that no current should be drawn from circuit and process can be done easily. That fixed voltage after buffer IC goes to arduino where it is programmed and processed; results in turning ON/OFF of LED's showing whether battery is charged or discharged depending on value of voltage being

fed into Arduino. Resistors should have values in kilo ohms so that current would be in mille amperes to meet the offset of buffer IC. If resistors of high wattage and values of mega ohm used then current will be in micro amperes and buffer IC offset will not reached and IC would not be in working state. This feature of power level indication using average power over an extended period affecting long term energy consumption on hardware separately is in accordance with from section: 4.2 of IEEE Std. 1621.

D. Brushing Motor Controller

The circuit consists of two transistors. One transistor takes a signal from Arduino controller and drives other transistor. Transistor which takes a signal is BJT 2N2222 and other one is TIP-122. Circuit works on 12V DC supply connected through a switch and fuse. Two transistors are used because single TIP-122 has high current rating and cannot be activated by Arduino directly. Transistor BJT 2N2222 is not used solely because stall current of brush motor is much high and BJT will not provide necessary current. So combination of these two gives a successful circuit to drive brush motor.

E. Power Supply to Sensors

All sensors used are rated at 5V but batteries are of 12V and 18V. So to give 5V to five IR sensors, 2 encoder sensors, one magnetometer and one Bluetooth module, this circuit has been designed and implemented. Regulator IC 7805 is used for converting 12V to 5V with current in milliamperes range. Capacitors are also used for voltage regulation and if there is some impulse which can disconnect power to sensors then these capacitors will act as source for maintaining connection to sensors. In case of disconnected state of power supply to sensors, White LED glows labeled as disconnected owing to section: 3.1.14 of IEEE Standard 1621.

F. Precautionary Circuit

This circuit serves as a main circuit consisting of bridge rectifiers, relays, transistors, diodes, fuses, Positive voltage adjustable regulator, LEDs, terminal blocks, and slim headers. This circuit consists of three parts. One is for motor battery safety and regulation of voltage, second for circuit battery voltage safety and third is for controlling motor battery through circuit battery and giving power to Arduino controller. In first part, one relay with diode in fly back mode, one transistor, one fuse, terminal blocks, one regulator and variable resistor are used. Firstly battery terminals are connected to terminal block shorted with inputs of bridge rectifier that is KBPC 5040 having a voltage rating of 1000V and 50A. Bridge rectifier is used to keep the supply voltage positive and secure the circuits if the battery terminals are connected in positive or negative direction. Signal from Arduino controller is given to transistor BJT 2N2222 which energizes relay and relay will allow motor voltage to go to fuse from rectifier and then it will go to regulator input. Regulator used is LM338k which is positive adjustable voltage regulator having a rating of 15A and can regulate voltage from 12V to 6V. This regulator is used so that there will be no fluctuations in output and motor works steadily. After adjusting voltage to 12V output will be shorted with terminal block and that block is now used for battery output both for encoder motors and brush motor. For more safety, fuse holders are used so that if there is any short circuiting occurs then it will not harm other components and fuse can easily be changed. Fuse used is of 10A rating as stall current for encoder motor is 7A and for brush motor stall current is 5A. LED along with resistor is placed just after regulator so that to ensure whether voltage is reaching to output terminal or not. In second part that is circuit battery safety consists of one relay with diode in fly back mode, one transistor, one bridge rectifier, fuse, terminal block and LED. Firstly,

battery terminals are connected to terminal block shorted with inputs of bridge rectifier that is KBPC 810 having a voltage rating of 800V and 10A. Bridge rectifier is used because whether battery terminals are connected in positive or negative direction, output will remain positive and circuits will remain secure. Firstly voltage from bridge rectifier goes to fuse and after this signal from Arduino given to BJT 2N2222 which energizes relay which results in switching of relay and relay will allow voltage to pass through it and shorted with terminal block which acts as circuit battery output terminal block and other circuits are powered up from this output terminal block. For more safety, fuse holders are used so that if there is any short circuiting occurs then it will not harm other components and fuse can easily be changed. Fuse used is of 2A because there is no component which drew more than 800 mA current. LED along with resistor is placed just after relay so that to ensure that whether voltage is reaching to output terminal or not. In last part that is controlling of motor battery circuit through circuit battery circuit consists of one transistor and one relay with diode in fly back mode. 7809 regulator is also used for giving power to Arduino through slim header. Signal from Arduino given to transistor BJT 2N2222 energizes relay connected to motor battery circuit. Energizing that relay results in close circuit of motor battery and hence controls motor battery through circuit battery circuit. Further for testing long wires are used for connecting between output terminal blocks of motor battery and circuit battery. Power Switches (section: 3.1.11 of IEEE Std. 1621) are also attached with these wires to turn on or off in any emergency.

VI. GRAPHICAL USER INTERFACE (GUI)

The main purpose of the GUI is to give all controls in the hand of user, so that he can use this product according to his needs. The software used for the programming of GUI of this device is Visual Studio 2012. As discussed, the robot can be used in manual mode as well as autonomous mode. Selection of the mode can also be done from this GUI. Visual Studio receives the data from COM port and displays it on the GUI after decoding. However, the communication via Bluetooth is 2-way i.e. it sends some data as a delivery report. The terms, indicators and labels used in GUI for power controlling and management are employed under sections: 4.3-4.6 of IEEE Std. 1621. A photograph of GUI for smart floor cleaning robot (CLEAR) is shown in Figure 2.



Figure 2. Graphical User Interface (GUI) for 'CLEAR'.

The significance and usage of different parts of the GUI are discussed below:

A. Battery Status

Batteries are the most important element in a robot because it provides the power source to all the electronic components. In order to divert the attention of the user towards battery status, the display of the battery starts blinking when the battery is less than 20% owing to sections: 4.1 & 4.2 of IEEE Std. 1621. A photograph of battery status is shown in Figure 3.

Battery Level	Display
80% - 100%	
60% - 79%	
40% - 59%	
20% - 39%	
0% - 19%	

Figure 3. Battery status.

B. Vacuum ON / OFF Button

An ON/ OFF button specific for the control of Vacuum Pump unit is also given in GUI. This button works exactly similar to Brush button. However, these both buttons do not affect working of each other at any instant. This control is inspired by section: 4.5.2 of IEEE Std. 1621.

C. Selection of Gears

These gears are similar to automatic automobiles in order to efficiently manage battery power, increase its operating time and control speed according to the need, thus referring to section: 1 of IEEE Std. 1621. Whenever gears are selected, a clicking sound is introduced to assure the user of gear change referring to section: 4.5 of IEEE Std. 1621. The gear selection can be viewed in Figure 4.

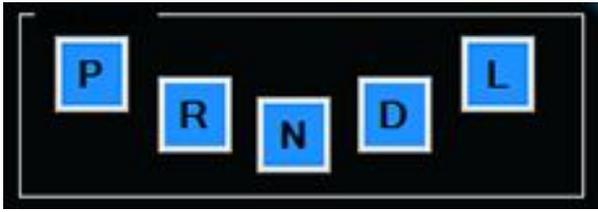


Figure 4. Gear selection controls.

1. Parking (P):

It keeps the device in sleep mode in which all the circuitry of the device is switched off. However, the Arduino board and the Bluetooth module are still active, so that the device can respond to any command received from the user interface in the laptop.

2. Reverse (R):

It is the reverse gear, in which both motors are run in such a way that the robot moves in the reverse direction. As discussed before, especially designed motor-controllers are used for changing the direction of rotation of motors. These motor-controllers also have the feasibility of speed control using Pulse Width Modulation (PWM). A tone is introduced in case of reverse motion as mentioned by section: 4.5.3 of IEEE Std. 1621.

3. Neutral (N):

Neutral gear acts as the intermediate gear in which the robot is not moving in any direction but still the circuitry is switch ON, waiting for the command from the user. It is to be noted that the brush motor and vacuum pump can be kept ON in this state of the device.

4. Drive (D):

Drive gear is the forward gear with full speed of the motor. The motors are synchronized using PWM in the motor-controllers, so that both tires rotate at equal speed. The synchronization of the motors in this way makes the robot move exactly in the forward direction without any tilt in any other direction.

5. Low Gear (L):

Low gear is designed for effective cleaning of the floor. In this gear, the robot moves in half of its full speed. However, the brush motor and vacuum pump work at the same speed, so net cleaning efficiency of the device is increased to the double of its normal efficiency.

D. Scheduling of Operations

Another icon of calendar is available on the main GUI for scheduling settings. A new GUI opens when the user clicks this icon. The user has to select the date and time for setting the cleaning schedule of the robot. Scheduling is done to avoid frequent unnecessary operation and make it a routine so that whenever a wake event is called from a sleep state, it manages its cleaning cycle itself in autonomous mode. Scheduling is done owing to Sections: 4.8 & 3 of IEEE Std. 1621. Moreover, the user can also select any one of the four options for the scheduling like Only Once, Daily, Weekly or Monthly. This can be viewed in Figure 5.



Figure 5. Scheduling settings.

E. Current Date & Time

The current date & time of the system is also displayed on the GUI for ease of the user and the same date & time is used in scheduling feature as mentioned by section: 4.1 of IEEE Std. 1621.

F. Mode Toggle

The robot can be used in two different modes i.e., automatic mode & manual mode. An icon is placed on the main GUI to toggle between automatic mode and manual mode. When the robot is in manual mode, icon shows A, showing that the user can click to convert it to automatic mode. When the robot is in automatic mode, the icon shows M, showing that the user can click on it to convert the robot to manual mode. Whenever mode is toggled, it is notified to user by a buzzer sound owing to section: 4.6 of IEEE Std. 1621.

G. Help Options

Another icon of help to ease the users is also available on the GUI which opens another GUI which contains a number of Frequently Asked Questions (FAQs). It also contains basic guide to open and service the device if required and the user manual is also available to enlighten them with basic symbols, power options and terminologies along with definitions as mentioned by section:1 and section:3 of IEEE Std. 1621.

VII. DISCUSSION ABOUT ROBOT OPERATION

The objective of this project is to make a vacuum cleaning robot which is fully autonomous and manual featured with user friendly interface. The vacuum cleaner is able to clean, brush and auto dispose-off. The robot named as CLEAR (cleaning entresol autonomous robot), it has variable speed and power efficient.

The testing of the robot showed that it can achieve almost all the functionalities which were planned to implement originally. CLEAR can be used in autonomous and manual modes as per user's will. During its autonomous mode, this robot can be scheduled with a proper date and time. When that time comes this product automatically starts and cleans the whole room and counter check pattern. When this robot completes the whole path it automatically cleans itself in the station from where it started cleaning. Moreover, manual mode is to save the energy of the robot and to clean the particular place. Customers are provided with the user friendly interface to operate the robot without any difficulty. CLEAR most importantly consumes extremely low energy which is 90W and take lead from the competitors. Vacuum cleaner has the reliable circuitry

and it has the safety circuit which rectifies different poles and restricts high voltage to affect the circuitry. However, the weakness of the robot is that it only cleans the small particles, it also doesn't find which particle to be cleaned and which is not to be cleaned. This robot also can't do wet cleaning. These two functions can be included in future enhancements of this robot.

The evaluation shows that our product is reliable and cost effective. It works with less energy consumption. The results showed that users from the university found no difficulty in using the product. Its results also showed that this product is user-friendly in both modes.

VIII. CONCLUSIONS

This paper shows the implementation of IEEE Standard 1621 IEEE Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments in terms of smart floor cleaning robot. The paper shows a better and simple approach to provide an overview of design of a simple robotic cleaners control design using gadgets and instruments easily available in Pakistani market. This robot (CLEAR) is specially made on the basis of modern technology. CLEAR has all the features which are required for a vacuum cleaner. It can work automatically and manually. It has the feature of the scheduling and it can auto drain itself. CLEAR has many competitors who are selling same product in high prices. This is first locally manufactured smart vacuum cleaner with all the features up to the standards of IEEE. Features of this robot can be enhanced with addition of mapping and high suction. As it has scheduling feature which can be operated with computer only, android and windows app can be made to make it little more user friendly. The target audience with all the features is middle and upper class of Pakistani community. It can also be used for the industries where cleaning with the help of human is toxic, vacuum cleaner can easily be used.

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