WHITE PAPER ON JETSONS ROBOTIC MODULE CLEANING SYSTEM

JETSONS ROBOTICS

ZERO

Jetsons' "Zero", Robotic module cleaning system is typically built, to undertake Wet & Dry cleaning in combination which conserves water resources, portable to manage smaller row lengths and without requirement of any extra railing infrastructure.

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Jetsons' Robotic Module Cleaning System

1. Introduction

Due to the increased cost of conventional energy and its harmful effects on the environment, the use of renewable energy systems has attracted much attention in recent years. In the case of photovoltaic systems, solar energy is converted into electricity. In photovoltaic systems, electronic devices known as photovoltaic cells are positioned on panels exposed to sunlight and transform the energy through the electron flow between two layers of semiconductors. Therefore, for photovoltaic cells to be operated at their maximum efficiency without loss of energy, it is necessary that the photons have free access to the photovoltaic cells of the photovoltaic panel. Experiments performed on solar parks, for example, show that the efficiency of a photovoltaic panel can decrease by up to 40% due to accumulation of residues on the surface.

2. Impact of Soiling

Thus, in terms of accumulation of dirt, in order to maintain the photovoltaic panel's energy efficiency, it is evident that periodic cleanings are required on the surface of them. Indicates that in about 8 weeks, in the absence of cleaning procedures, the accumulation of dirt on the surface of the panels is responsible for the drop of about 6.9% in system performance. When the cleaning procedure is performed regularly, there is a positive impact of 9.8% on the capture

3. Technical Specifications

- Supports Dry & Wet Cleaning.
- Portable from Row to Row
- Row Heights supported 2 M , 4 M
- Row Length Supported 2000 M
- Re-Chargeable Li-Iron Phosphate Battery
- Cleaning Speed – 8-10 meter/minutes.
- Remote / Local programmable controls
- Brushes - 6-6 Soft Nylon bristles
- Travels over aluminum frame of module
- Compatible with most of modules. Controller
- No rails required till module gap is more than 150 mm
- Dimensions (HxWxB) – (2/4)x 0.14 x 0.5 M
- Weight – 30 Kg.
- Guarantee - 1 Year or 3 Year(express)

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4. Features of Jetsons' Robotic Module Cleaning Solution

a. Unique Features – Amphibious (A), Modular (M), Portable (P)

Jetsons' Robot family has distinct competitive advantage over the similar products available in the market called AMP.

"A" depicts, ***Amphibious***, as the Robots are able undertake Wet as well as Dry cleaning cycles just by replacing cleaning brushes by the operator. This is made simpler by introducing patented technology for locking of the brushes. This feature helps planning combination of Wet and Dry cleaning cycles , reducing water consumption in the projects where the soiling is moist but water availability is scares. This feature reduces water consumption by almost 75%, while keeping the cleaning quality in tact.

"M" depicts, ***Modular***, Robot families which exceeds 4 M height uses chassis on which central robot moves and cleans the desired modules in multiple passes. Modular approach helps reducing the weight of the Robot, still serving customer row heights.

"P" depicts, ***Portable*** , Robots movement is designed with a understanding that Robot shall be movable from one Row to another with the help of 2 member unskilled team members. This feature is useful where project has numerous small / midsize rows and placing dedicated robot per row may not be commercially viable. With very moderate weight of 35Kg, movement of Robots from one row to another does not take more than 3 min.

b. Module Frame based movement – Jetsons Robots' movement is designed to move over the Aluminum frame of modules. The benefit being no additional rails are required to move the Robots on modules. Due special idling wheels attached to the posterior part of the movement, helps moving Robot even if there is module misalignment of 150mm.

In the event where Module Aluminum frame is not available (like frameless modules) or module gap is more than 150 mm, Robots can be maneuvered over GI rails, extra fixed. Such mechanism is used when System is to be used for fully automated Robotic system and Robots are expected to move from one Row to another without any manual intervention.

Module frame based movement helps implementation of Robot without putting additional rail. This not only reduces implementation time but also total cost of ownership of the project

c. Cleaning Brushes – Cleaning brushes used in Jetsons Robotics are specially designed to offer 90% of cleaning efficiency at 200 RPM. The Brushes are made of Split soft bristles which are always in contact with module toughen glass. There are 2 brushes , 2M length each , moving at speed of 200 RPM. The brushes are technically different for Wet and Dry cleaning. However the brushes can be replaced by the operator due to patented socket technology.

Specification of Brush Bristle

- Split end Nylon Bristle 6x6
- Make – DuPont
-

d. Variable Cleaning Quality

It is clearly known that the cleaning quality of Robots is directly proportional to Cleaning quality. Jetsons Robotics offers soft controls on the Robot operator panel to adjust quality of Cleaning.

The Robots offers 2 movement speeds, 0.15 m/s and 0.20 m/s. Since the cleaning quality is directly related to amount of time cleaning brush is in contact with module surface. Hence 0.20 m/s speed selection will offer lower degree of cleaning quality (80%, quick cleaning option) compare 0.15 m/s (High grade option) . At the high grade option Robot shall move slower hence the total yield may be lower by at better cleaning quality (90%).

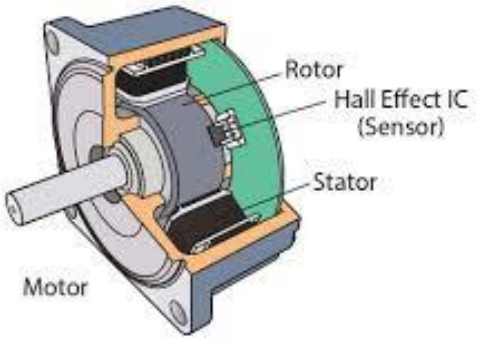
The speed / Quality option can set through control panel by operator (Quality= High/Low)

e. Mechanical Movement.

Robot mechanical movement is fitted onto special Aluminum alloy (Aluminum 6061) which is light but tough. The Aluminum frame moves over three sets of Polyurethane (PU) rollers namely Driving wheels (8 Nos.), Support Wheels (8 Nos) and Idling Wheels (3 Nos). While Driving Wheel move the Robot framework and Cleaning Brushes, Support wheels ensures Robot's movement in line with module frame. Idling Rollers ensures misalignment of the module frame are absorbed during movement.

f. Electronic Movement.

Entire electronic movement is based on Brush Less Direct Current motors (BLDC) . Use of BLDC technology helps maintenance free operation at lower noise level. Consumes less power and hence can sustain high distance travel in given size of the battery. Due Basic DC type, does not require separate DC to AC conversion while using Solar based operations and hence reduces the weight of the Robot. No change of Brushes required periodically which could be additional running cost.

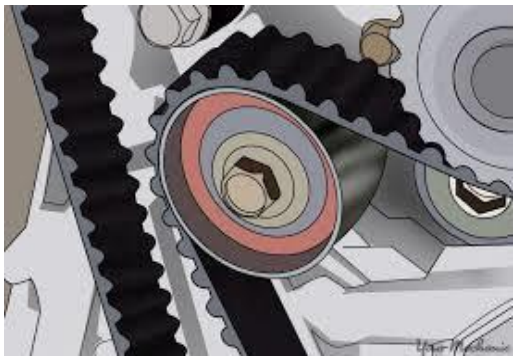


Driver Motor Specifications

- Rating 120 W, 24 V ,
- Current Consumption – 4 A continuous
- Lifecycle – 6000 Hours

g. Speed Transmission System

The prime mover movement is transferred to Brushes and Rollers using high grade time belts. These belts has least maintenance, easy to replace, no lag and lower weight to contemporary sprocket chain transmission.



- Material - Kevlar reinforced rubber belts
- Life - 3000 Hours
- Benefits - Self lubricating

h. Communication Protocol

The unit has two communication protocols.

- 430 MHz Radio Frequency Protocol which helps managing Robots remotely upto distance of 1 KM from Robot. Multiple RF Hubs can be installed spanning maximum distance of 2 KM between the hubs to manage multiple Robots across large geography.
- WIFI connectivity , helps managing Robots remotely across any geography

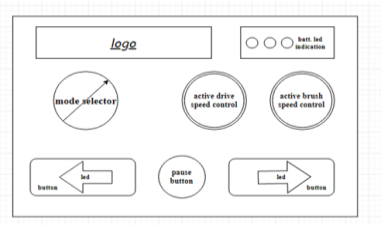
i. Central Processing unit-

The entire logic of the Robotics management is built around very powerful central ARM Cortex - M3 based Microcontroller. The controller is equipped to connect to local control or web based application

j. Operator's Panel

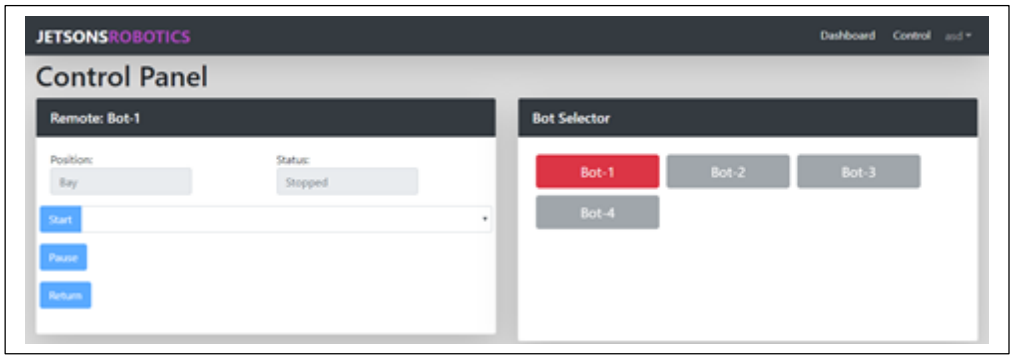
The Robot carries a local Operators panel having controls like

- Manual / Auto
- Start / Stop
- Emergency indicators & Alerts
- Cleaning Quality setting



k. Remote Management

The Robots can be remotely managed within the periphery of 1KM due to RF communication protocol available onto the Robots. However Robots can be connected to WIFI and managed from remote location. Separate remote management application is available to manage multiple Robots from multiple site simultaneously



l. Self Charging through Solar Panel

The Robots houses Li-Ion Phosphate chargeable batteries which can be charged by the solar panel of 100 Watts, hosted onto the upper surface of the Robots during a day. It uses Phocos MPPT based charging system. Unit also supports separate solar based chargers where extra batteries can be charged offline.

m. Sensors and Alerts

- Position & Edge detection – These mechanism uses ultrasonic sensors to detect end position. Unlike other sensing mechanism, it does not require any additional stoppers, limit switches, induction sensors to be installed on the modules to identify the edge.
- System has facility to set alert based on amount of battery left to reach back home position. The algorithm is made such a way that on reaching to back home alert, Robot shall return back to home position while in between the cleaning process.

n. General Maintenance

The unit is compliant to IP 65 norms and hence is tested for severe field conditions. There is no regular preventive maintenance suggested. Following are spares which may be required to be changed over the usage

- Cleaning Brush – 300 Hours
- Batteries – once in 2Years
- Motors – 6000 Hours
- Gearbox – 4000 Hours
- Timing Belt – 3000 Hours

o. Product Guarantee

Standard Guarantee – 1 Year free replacement of spares against manufacturing defects

Following parts are not freely replaceable during warranty period

1. Chargeable Li-Iron Phosphate batteries
2. Cleaning Brush

5. Various Videos of "Zero" Robot

a. Zero Robot working on site - https://www.dropbox.com/s/flh491ijzx24ym9/Actual%20Sit.mp4?dl=0

b. Video depicting portability of the Robot. https://www.dropbox.com/s/3aago1wc44xp9gh/VID-20180627-WA0121.mp4?dl=0

c. Video depicting Chassis based modular Robot. This Robot can be used for various row heights of 4M, 6M & 8M https://www.dropbox.com/s/clrohajg75dqozc/rack%20based%20robot.mp4?dl=0

6. Partner Network

Jetsons' Robotics is a channel friendly organization and shall have various channel partners to address market needs. Currently, Plasmaberry has been appointed as Master distributor of Jetsons' Robotic Module Cleaning Systems for India. The expected channel partners are

1. Center Of Excellence Partner (COEP)
2. Sells Channel Partner (SCP)
3. Delivery Service Partner (DSP)

Plasmaberry, being already into business of Solar services like Module Cleaning, Operations & Maintenance (O&M) and Module cleaning systems implementations, already has service network at strategic locations. The same locations shall be undertaking sell and services of Jetsons' Robots at start. Plasmaberry shall act as center point to create partner network for Jetsons' Robotics.

Center of Excellence Partner Program (COEPP)

Jetsons Robotics is in the process of creating Center of Excellence across the country at strategic locations, to create better customer experience through COE Partner Program.

1. Objectives of the program

- To create facility for demonstrating full features of Zero Robot to aspiring customers at actual working site
- To improve customer experience about the product
- To evaluate product performance parameters under actual field testing conditions

2. COE Partner Program Overview

- COE shall be created at defined strategic locations across country by appointing partners (COEP).
- Jetsons shall certify COE partner and it's location and train COE team for support services.
- Plasmaberry shall be responsible for
- Fulfilment of COE infrastructure and it's commencement.
- Approval of Proof of Concept (POC) customer. Only for approved customer, partner shall be paid for COE instance as per defined rate.
- Selection / appointment of COE partner for POC delivery.
- Conduct periodic audits on COEP centers for quality and compliance.

3. Benefits of COE Partner

- Flat price discount on purchasing of Robots and it's peripherals to COE partner for setting up Center of Excellence
- Additional revenue stream for conducting demonstration sessions with aspiring customers and adding value to sales cycle
- Additional discount on products, used for self-consumption.
- Inclusion in partner co-funded marketing umbrella program to Increase their own market penetration.

4. Expected Role of COE Partner

- To maintain suggested Robotic infrastructure at defined COE location
- Run demonstration of Robotic cleaning to any (qualified by Jetsons / Plasmaberry) new customer
- Make local logistic (stay / food / travel) arrangement for visiting customer at defined cost.
- Cannot sell COE infrastructure in Market
- COE partner can be sells & delivery partner as well