Transmission Line Inspection Machine

HEALTH ASSESSMENT OF TRANSMISSION NETWORK

Pranav Pandey, Deepak Verma

Electrical Engineering Department, Institute of Technology, Nirma University

***Abstract*-The purpose of this project is to design and fabricate a self-adjusting and self-balancing machine capable to traverse on the HV Line. The machine shall have the capability to avoid the obstacles on the Transmission Line such as cable spacers, suspension clamps and tower crossing. The proposed mechanism is stable and fast in overcoming obstacles. The machine will provide real time image of the Transmission Line to the utility. The future monitoring system will be equipped with GPS Tracking system.**

***Keyword* -Transmission Line Autonomous Inspection, Cost-effective, Spacers, String Insulators, Suspension Clamp, Linear Actuator, Catenary, Ultrasonic Sensor.**

I. INTRODUCTION

At present the Power Transmission Lines are monitored by Electric line workers who manually inspect the physical condition of overhead lines [1]. However the job of a Line worker is demanding in nature and has safety issues. The Transmission Line Inspection Machine is designed to overcome the above challenge and provide cost-effective solution for inspecting the line.

A. Design Challenge

Major challenge involved in the project is to overcome the obstacles on the Transmission Line. The machine is designed to be self-balanced without affecting its catenary shape being light in weight (15kg). It is stable and fast while overcoming obstacles due to the robust design.

B. Cost-effectiveness

The average annual expense incurred by the State Electricity Board for Power Line maintenance is approximately 10-15 Lakhs. Some countries also use helicopters for inspecting HV Line which further increases the maintenance cost [1]. In comparison to this the manufacturing cost of this machine is 0.5 Lakhs exclusive of machine maintenance and repair, which significantly decreases the expenses.

C. Transmission Line Obstacles

The machine is designed to work on high voltage (220kV) bundled conductors (moose) [2]. The obstacles on the line include cable spacers, clampers, vertical string insulators and horizontal string insulators as shown in Fig.1. Due to sag in the power line the machine needs to generate sufficient torque at certain distance along the line to overcome it.

TABLE I

Sr. No	Major Machine Components	Qty.
1	Aluminium Chassis	2
2	Gripper Modules	4
3	Linear Actuator	2
4	High Torque DC Motor (12V, 120kg-cm Stall Torque, 10rpm)	2
5	High Torque DC Motor (12V, 20kg-cm Stall Torque, 60rpm)	2
6	Telescopic Slider	2
7	U-Grooved Wheels	2

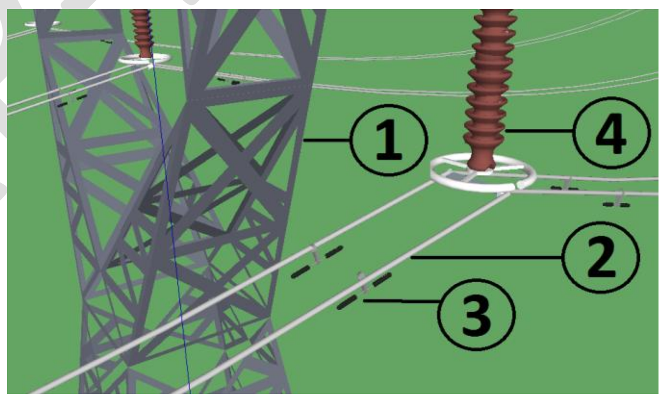

Fig.1: 1. Tower, 2.Bundled Conductors, 3.Suspension Clamps, 4.Vertical String Insulators [8]

D. Construction

Some of the important components utilized for fabricating the machine are listed in TABLE I.

The machine comprises of two chassis: (i). Main Chassis, (ii). Support Chassis. Each is made of Aluminium square cross-section hollow pipes to maintain a light weight and robust structure. The joints are welded using argon arc welding technique.

Main Chassis is further divided into two halves, wherein each half is equipped with a U-grooved wheel driven by a high torque DC Motor [9]. Motion of both the halves is independent of each other. The wheel & motor assembly is further connected to a DC motor using gear system to rotate this assembly perpendicular to the axis of rotation of wheel as shown in Fig.2.

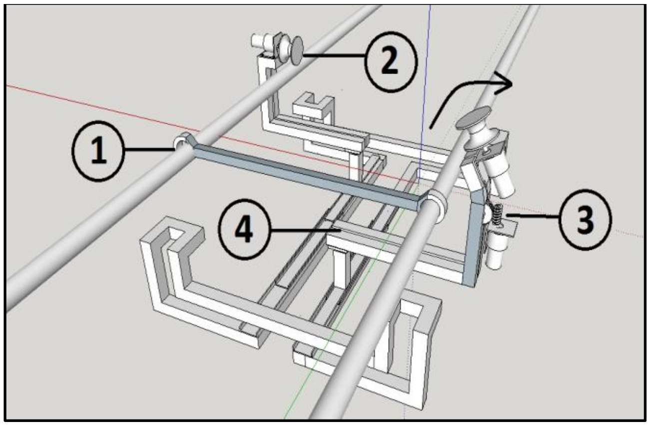

Fig.2: 1. Spacer, 2.U-Grooved Wheel, 3.Gear Assembly, 4.Main Chassis [8]

Each half of the main chassis is connected to the base of support chassis using a linear actuator as shown in Fig.2.The linear actuator is placed on the telescopic slider connected to support chassis. The support chassis consist of four gripper modules [14] at each corner as shown in Fig.3 in order to maintain the stability of the machine while avoiding obstacles. Each gripper module comprises of gear system connected to a DC motor.

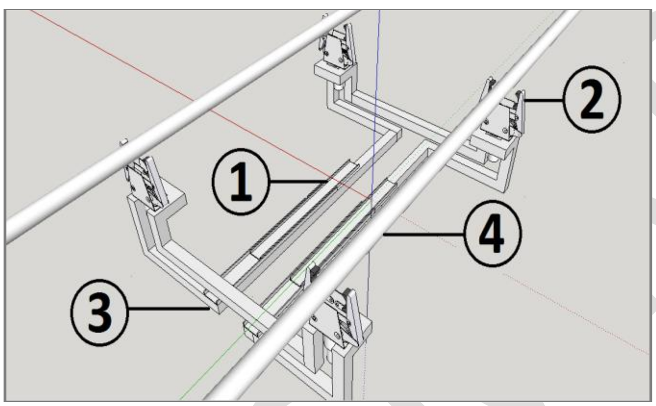

Fig.2: 2. Telescopic Slider, 2.Gripper Module, 3.Support Chassis, 4.HV Line [8]

E. Operating Mechanism

The operating mechanism of the machine can broadly be classified into three conditions depending on the obstacle.

1) *Normal Operation*

Under this condition the machinetraverses on the line with the help of both the u-grooved wheels which maintains its stability. In this condition the machine doesn't encounter any obstacle. The speed of machine under normal condition is 0.3km/hr.

2) *Machine encountering small obstacles*

Under this condition the wheel and motor assembly moves vertically upwards with the help of linear actuator and rotatesin perpendicular direction to the wheel axis thereby avoiding small obstacles such as spacers, vertical insulators and suspension clamps. Meanwhile, the gripper grips the transmission line and the wheels move forward thereby avoiding obstacles.

3) *Machine encountering horizontal insulators*

Under this condition the linear actuator adjusts the support chassis so that the gripper at the front end grips the conductors firmly. Meanwhile the wheels at left half of main chassis moves forwards and sets on the catenary shaped line. Similarly, the rear end grippers grip the line and right half of main chassis sets on line.

F. Electronic Control

At present the machine is designed to operate on rechargeable battery. Some of the major electronic components that will be utilized in the circuitry are listed in TABLE II.

Five Ultrasonic sensors [13] are utilized to detect the obstacles on the Transmission Line. These sensors are selected due to its better work efficiency in external environment. One sensor is placed at the center of the machine to detect spacers, suspension clamps etc. Two sensors are mounted at the front end to detect the vertical string insulators and two for detecting horizontal string insulators.

8-Channel Relay board [11]has been used for switching of high torque DC Motors and Linear actuators. These boards are controlled electronically through a microcontroller based development board. According to the output of the five sensors, relay switching occurs providing actuating signal to the actuators thereby executing the desired mechanism.

An ultra-micro Camera [12]is used to monitor the physical condition of the line. The transmitter transmits the signal to the Monitor Headset. The Camera is equipped with a pan and tilt motion using servo motors, to obtain a broader field view.

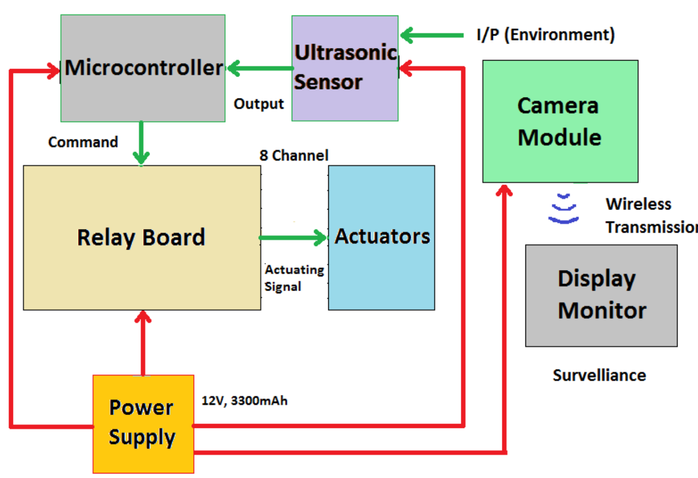

Fig.3: Block diagram of Electronic Circuitry

TABLE II

Sr. No	Major Machine Components	Qty.
1	Ultrasonic Sensor (4m range)	5
2	Relay Board (8 Channel)	2
3	Headset Monitor	1
4	Li-Po Battery	2
5	Ultra-Micro Camera	1
6	Microcontroller based Development Board	1

G. Faraday Cage

A special Faraday Cage needs to be designed in order to prevent the magnetic and electric fields from interrupting with the electronic circuits. The machine will be covered with this metallic cage made up of stainless steel threads that will help it withstand the high voltage [8].

H. Scope for improvement

At present the machine is not self-propelling. It is working on two rechargeable battery of 12V, 3300mAh.
For one charge cycle both the battery can power two DC motors connected in parallel at full load for duration of 60 minutes. This result suggests that after every hour the battery needs to be charged again.

Hence, adequate charging mechanism needs to be designed to obtain long operation time. The future monitoring system will be equipped with a GPS Tracking system to determine machine's location.

This system can also be utilized to determine the electric field surrounding the conductors which can serve as an important data for the utility to assess the health of the power system.

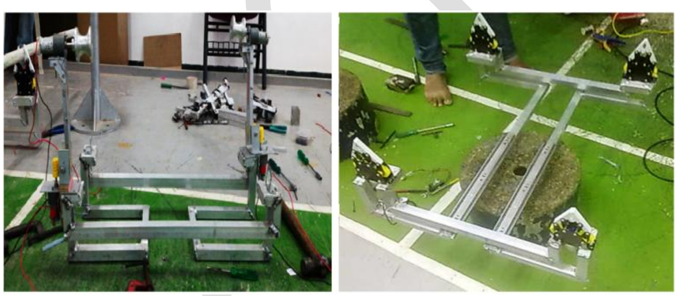

Fig.4: Glimpse of fabrication process

II. CONCLUSION

The Transmission Line Inspection Machine can serve as an effective tool in the future for the Power Industry for autonomous maintenance of HV Lines. This will result in a significant reduction in the labor charges without compromising with the safety of line workers. The machine can be used to obtain various important data required to assess the health of the Transmission network.

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