Emerging of Recent Trend in Transmission Line System using Robotic Technology

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ABSTRACT

Managing overhead transmission assets-including towers, conductors, insulators and other components are a costly and sometimes dangerous proposition. Many lines are located in remote, rugged environments. Frequently, inspection workers conduct helicopter surveys or must climb towers. Some equipment cannot be inspected due to hazardous conditions or access restrictions. Robotics inspection system being developed by us promises to reduce costs, enhance safety, and expand coverage while improving reliability.This robot provides a real-time monitoring of physical threats or damage to electrical transmission line towers and conductors as well as providing operational parameters to transmission line operators to optimize transmission line operation. These transmission lines are located at remote area where the monitoring was not providing, to rectify this problem this robot is designed & aims at enhancing the transmission system by minimizing its drawbacks like insulation damage, ageing, electrical outages (due to high risk trees) and ground clearance which are faced manually. By using automated system human involvement can be minimized. In Our proposed robot, we can overcomeall these problems. The data collected in this system can be transmitted to control room by providing the receiver and transmitter in each pole up to the end point. The communication between end point and control room takes place using existing infrastructure like cell or landline, internet or any other communication infrastructure. If line to ground monitoring is required we can transmit and receive the data directly.

Key words: assets,propositions,rugged,hazardous,reliability,enhance,real-time

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1. INTRODUCTION

The power generating capacity of our country is very low but the consumption rat is very high & also the demand is also high. So we must use the power efficiently inorder to obtain efficient power transmission we must use robotic technology.Our robot consists of a current coil (insulation detector), infrared sensor, RC servomotors (it is an integral part of the robot), carbon composite frames, high definition camera, rotating shaft, vibration sensor, micro wheel, transmitter & receiver and monitoring device.Current coil is used to determine the flow of current through the live transmission lines and the variation in the current coil reading gives the quality of insulation. It is also used to determine the transmission voltage level. Infrared technology gives us the ability to "see" and measure temperatures on defective components and the normal wear, chemical contamination, corrosion, fatigue and faulty assembly in transmission system.Overheating can occur in virtually all electrical components and hardware including generators, transformers, pole top connections, insulators, disconnects, jumpers, shoe connections, fuse connections, switchgear, starters, contactors and any other hardware one might imagine. In transmission and distribution systems thermo graphic surveys can help cut production losses and prevent the eventual failure of these systems. Utilizing infrared thermography for electrical inspections can help to obtain the followings:

- set maintenance priorities
- prevent unplanned outages
- reduce loss
- reduce liability
- evaluate repairs and
- maintain high performance.

Infrared sensors also detect the ground clearance and wheels positions.

RC servo motor is used for mechanical action of the robot. Without this motor this robot could not move in anyway and would only be able to perform stationary actions that require no movements. Carbon composite provides us high strength and less weight insulating frames. Solar panels provide power to the robot for operation by converting the solar energy into electrical energy.

Vibration sensors are used to detect the hissing noise. High definition camera is used to view ageing problems and disturbance (trees) which cause electrical outages. In the rotating shaft, infrared red camera, high definition camera and electrical coil are mounted to monitor the entire cross sectional area of the live conductor. Micro wheels for the robot movement are fixed over the live conductors. Transmitter is used to transmit the information's gathered by the robot and receiver is used to receive the information from transmitter.

PROBLEMS & SYMPTOMS OF DETERIORATION IN TRANSMISSION LINES

Transmissionlines are exposed to variety of factors, such as corrosion and wind induced vibrations, which cause different problems and limit of their life time of the lines. This damage can be classified as two main groups:Damage to the insulators and damage to the conductors

DAMAGE OF INSULATORS

The insulators are affected by impact of weathering, thermalloading, electro thermal causes ,cement growth etc.., Temperature difference between hot sunny days and freezing cold nights as well as the heat generated by fault current arcs causes thermal cycling, which produces micro cracks and allowed water to penetrate into the material. Thus it causes damages to the insulators

DAMAGE OF CONDUCTORS

The steel reinforced aluminium conductors(ACSR) are one of the most popular conductor types.The most important phenomenon that degrades such conductors is corrosion of aluminium strands. Pollutants and moisture, in the form of aqueous solutions containing chloride ions, ingress into the interface between the steel and aluminium strands and attacks galvanizing protection of steel, which leads to galvanic corrosion between iron and aluminium. In addition to corrosion, wind induced vibration can make severe damage to the mechanical system

SYMPTOMS OF THE TRANSMISSION LINE DAMAGE

Damage the line can be detected through investigation of their symptoms .Most of the line problems produces unusual partial discharges. Whenever the electric field intensity on the line surface exceeds the breakdown strength of the air, electrons in air around the conductor ionize the gas molecules and partial discharges, namely corona effect, occur. High frequency partial discharges produce radio noise in ultra high frequency range. In addition to the noise, discharges send a current to the line .This current can also be used to detect faults. Depending upon the weather, age of the line, problem conditions and other factors, level of the discharge can also be different.

ROBOTIC INSPECTION

Robotic inspection involves the use of autonomous or remotely controlled machines that incorporate imaging, sensing and other technologies to assess the condition and status of transmission system components. The idea is to reduce or eliminate human exposure to potentially dangerous environments while collecting the date required for meeting stringent reliability standards on tight maintenance budgets.

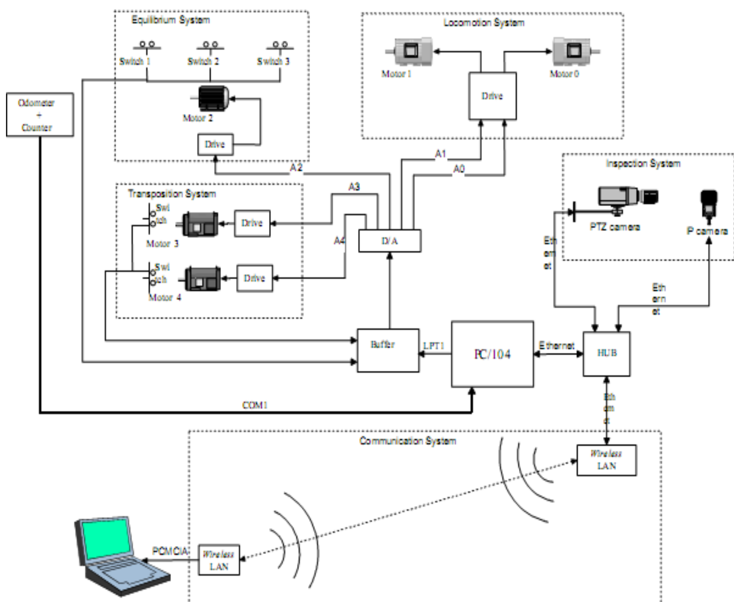

Figure1: Layout of the robotic inspection system

STANDALONE ROBOT FOR AN INSPECTION OF TRANSMISSION LINE

The autonomous transmission line inspection robot is intended to reduce or eliminate the need for helicopterover flights while supporting a transition from scheduled to condition-based maintenance on both existing and new corridors. The motors will run on power harvested from shield wires, supplemented by output from on-board solar panels. High definition cameras and other equipments will identify nearby trees that could pose a risk to wires, evaluate right-of- way encroachment, and assess component condition by comparing images taken from different locations and at different times. Simple electromagnetic interference detectors will identify discharge activity and other indicators of faulty equipment.

Figure2: Sample model of the robot with solar panel.

MOUNTING ENCLOSURE:

The heart of the system is the electronics package. It is located on high-voltage transmission line that may have a line to ground potential up to or even greater than 500 kVac. The package is required to protect from weather and the effects of corona. The mounting enclosure provides these two requirements and must be vibration free and "hot stick" deployable to prevent de-energizing the transmission line when installing the sensor platform.

Figure3: Mounting enclosure

VIBRATION SENSOR

A tow-axis accelerometer (vibration sensor) and two pass band filters provide the vibration detection interface to the sensor DSP. The vibration sensors are located on the circuit board and oriented such that vibrations in the plane of the board are measured relative to the axial direction of the transmission line conductors, Twopass band filters with gain are used to amplify the vibration signals and reject all out of band signals that are not considered to be caused by tower tampering. The resulting signals are delivered to the sensor DSP where the sensor time domain signals are converted to the frequency domain through the application of a Fast Fourier Transform (FFT).Once in the frequency domain, known vibrations not related to tampering can be effectively filtered out through simple addition and subtraction. Signals removed include those related to the transmission line 60-Hz fundamental and its harmonics. The resulting frequency spectra is then summed and compared to a threshold, and the valued that exceed the threshold are reported to the operator via the onboard radio link and the endpoint.

INFRARED SENSOR

A pyro-electric infrared sensor with an infrared pass band from 4 to 12 microns, an IR lens and a pass band filter provide the motion detection interface to the sensor DSP. The IR sensor sensitivity is located in the human body's black body radiation range giving a warm object(human or animal) a high contrast against a warmer or colder background. The sensor responds to a change in radiation (dIR/dt) over a period of time within its pass band that detects movement as opposed to detecting the absolute level of IR radiation. This characteristic gives the sensor the ability to detect the movement in hot or cold or night or day conditions. A specially designed IR lens with a focal length of about 60 ft is used to focus an object the size of the human body as viewed from above and located at the base of the tower on the sensing elements. An electrical pass band filter with gain is used to amplify the low-level signal from the sensor and rejects changes in the output that are out of band with the expected movement of warm bodies at the base of the tower. The output of the sensor and lens is delivered to the DSP where further processing takes place to reject naturally occurring IR changes.

COMMUNICATION LINK

Each TLSM (Transmission Line Security Monitor) is intended to be mounted on a conductor close to the insulator holding it at each tower of a transmission line or a section of a transmission line. From this vantage point it can detect warm body movement at the bade of each tower and vibration associated with that tower. When thresholds are exceeded, a message is generated and transmitted to the transmission line control room to alert operation that a possible threat to a tower is occurring. The distances between the operator and the alarming TLSM can be several hundred miles away as well as in areas where communication infrastructure does not exist. To implement communication each TLSM contains an RF transmitter that is capable of acting as a network node in a one-dimensional network transmitting information from each sensor to the operators.A custom designed antenna is used to transmit and receive electromagnetic radiation from each of the sensor platforms completing the communication link. The antenna is located in a slightly conductive radome further protecting the antenna and cabling from the high electric fields.

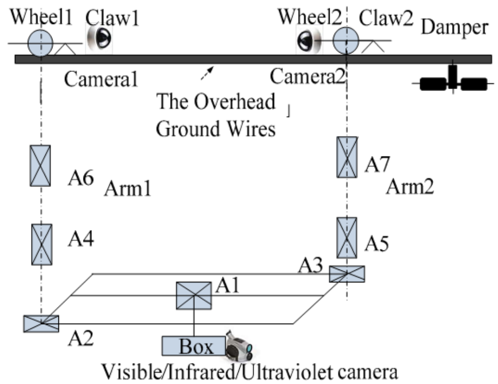

Figure4: Working process

ENDPOINT

The endpoint performs a supporting role for the sensor platform in that it completed the link between the sensor platforms and the transmission line control room operators. Its function is to provide an information connection between the sensor platforms and existing communication infrastructure such as land line telephone, cell phone, internet, or any other means available to deliver information to the operators. Together the sensor platforms and at least one endpoint make up the TLSM.Itsupported two-way,communication protocol, packet encoding anddecoding, and short-term energy storage. It is intended tobe located where information infrastructure exists such as the power generating end or the load end in a substation.

MECHANICAL SYSTEM

During the development of the robot, mechanical system able of moving along a cable of a transmission line is needed. The methodology of development of the mechanical system includes the study of wind effects on the robot. Depending on the results, the configuration of the robot could be changed, since it is foreseen, in this paper, the visualization of the conducting cable, also. Then, some possible configuration is studied to implement the requirements and, finally the moving power is calculated, based on the robot mass forecast, and the pulleys of vehicle traction system.

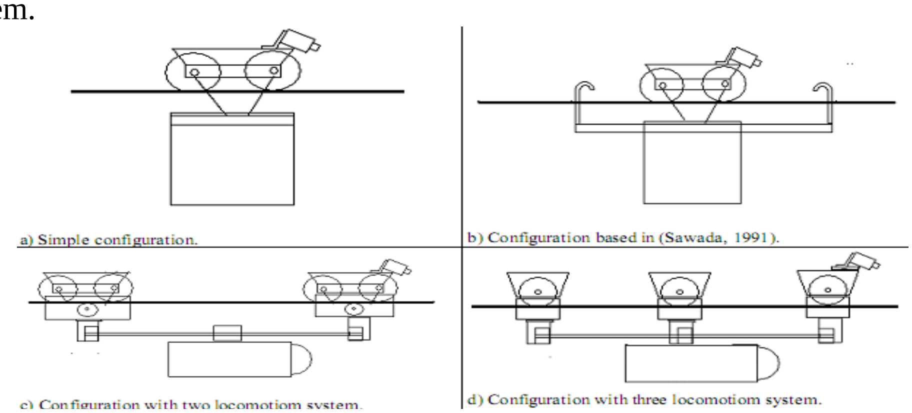

Figure 5: Mechanical configuration

MAIN FACTOR TO BE CONSIDERED-WIND EFFECT

When the robot is placed on the transmission line, the main factor to be considered is wind effect because the level of the transmission line from the ground is very high so the speed of the wind is also high. It causes the robot to oscillate or it may be fallen from the transmission line. During the study of the wind effect on the robot, two hypotheses are considered: the robot is modeled as a simple pendulum or as a two opposing pendulums. The results pointed here are a qualitative, but lead to conclusions about the influence of the shaped and configuration in the reduction of the amplitude of oscillation and in the improvement of the stability of the system.

SIMPLE PENDULUM MODEL

The model of simple pendulum, serving as comparison with the model of opposing pendulums, emphasized the level of interference of the form on the oscillations. For this reason, cylindrical and parallelepipedical forms for the robot were studied.

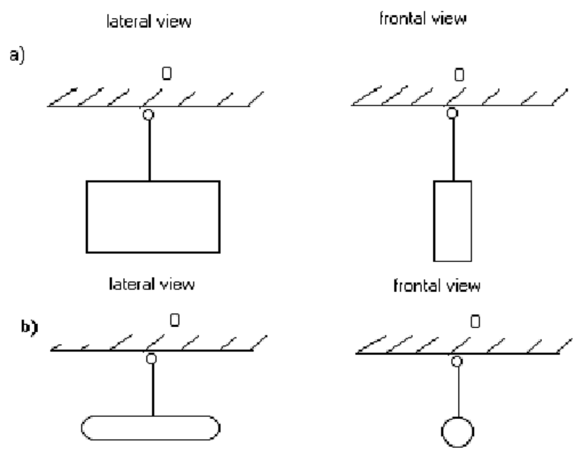

Figure 6: Simple pendulum model a) parellelopipedical b) Cylindrical

From the above study, we concluded that

- In the model of simple pendulum was possible to show that the hydrodynamic shape is an important component on the amplitude of oscillation of the robot.
- Also in the model of simple pendulum was possible to directly show that the increase of the area caused an increase of the amplitude of oscillation.

OPPOSING PENDULUM MODEL

A configuration that diminishes the amplitude of oscillation of the robot due to the effect of the wind is two cylinders, one above and other below the cable. In this case, preserving the input data of previous models, allowed a qualitative comparison.

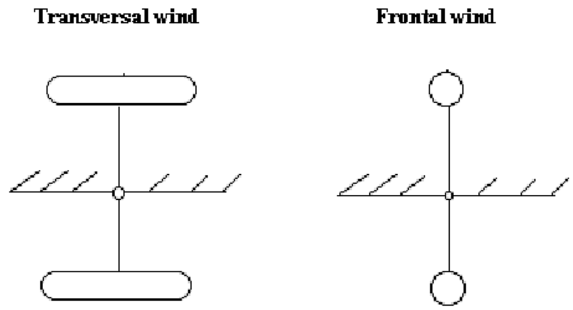

Figure 7:Schematic representation of opposing pendulums

From the above study , we conclude that

- The proximity of the dimensions and geometry of the upper and lower bodies decreases the amplitude of oscillation.
- As the ratio between mass of the lower and upper body increases the amplitude of oscillation decreases. If the two bodies have the same geometry and dimensions, the amplitude due to the wind effect is null(equal the zero).
- When the mass of the upper body is bigger or equal to the lower, the system becomes unstable.

POTENTIAL BENEFITS FROM ROBOTIC TRANSMISSION LINE INSPECTION?

An aging asset base, stringent vegetation management and reliability requirements, and continuing budget pressures increase the need for through, timely, and cost-effective monitoring and condition-based maintenance along the entire length of transmission lines. Robotic inspection promises to deliver actionable condition assessment data and information from environments that cannot be readily accessed today, as well as to improve worker safety.

CONCLUSION

In this paper, a robot for the inspection of transmission lines was developed, decreasing the time interval of line disconnection and increasing the safety of the maintenance procedures. This mobile robot can be used as basis for future developments, generating a more complete system for energy transmission lines services. Among future developments the implementation of a tool to place to remove aircraft warning spheres is foreseen, as well as tools to carry out repair in damaged cables; and, finally, a system to execute autonomous inspection through the recognition of damages in the ground cables. In order to use the power efficiently we need automated system.

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