TRANSMISSION LINE INSPECTION ROBOT

K Geetha ME (PhD)[1] | Yuvarani C[2] | Vijay shanthi A[3] | Soniya A[4] | KamachiLalitha R[5]

[1](HOD, Department of ECE, KGiSL Institute of Technology, Coimbatore, India, geetha.k@kgkite.ac.in)
[2,3,4,5](UG Scholars, Department of ECE, KGiSL Institute of Technology, Coimbatore, India)
(yuvarani.181@gmail.com[2], vijayashanthi0394@gmail.com[3], soniya.sonu2010@gmail.com[4], lalitha0601@gmail.com[5])

Abstract— *This paper describes the development of a mobile robot capable of inspecting the long transmission lines that runs across the cities and towns. The mobile robot walks on overhead ground wires in 500KV power tower. Its ultimate purpose is to automate to inspect the defect of power transmission line. The robot equipped with sensors, detection instruments and data communication apparatus, is capable of inspecting transmission system. Visible light cameras are installed to capture the images of the transmission lines at regular intervals of distance and the communication system is based on wireless Zigbee protocol. The captured images will be sent to the control area, here there is a database of the original images of the transmission line. The images that are received are compared with the databases using Digital Image Processing, and thus defects are found. A prototype robot was developed with careful considerations of mobility.*

Keywords—robot,power transmission,navigation,inspection

1. INTRODUCTION

The proper maintenance of High-voltage transmission lines is of vital importance, since any problem may result in the interruption of electricity, with many negative impacts to health, sanitation, transportation and safety. Preventive maintenance is the best way to avoid problems with infrastructure, by detecting them in an early stage and responding accordingly with action plans for repairs or improvements. However, inspection of high voltage transmission lines is a very risk operation, as workers must move on the lines several tens of meters above the ground, in very demanding and stressful conditions. In order to make this work safer, sometimes the transmission of electricity is interrupted for the inspection operation. However, this may not be possible at all times, since it would overcharge other parallel lines. In times of high demand, such as in summer and winter, the utilities may have to pay hefty fines for the reduction in capability to provide electricity.

The use of helicopters has been proposed as a way to improve safety and speed of inspection operations. Even though video shot from helicopters provides general information regarding the conditions of the lines, and the vegetation around the towers and lines, this method cannot provide details of the lines regarding scratches, minor faults or corrosion, which are early signs of problems that must be repaired before the lines are seriously damaged. This paper aims to overcome the above mentioned drawbacks. In the proposed system, we can design a new system to monitor the transmission line.

The monitored information is transmitted using wireless communication. A mobile robot that can crawl along the overhead ground wires to perform part of power line inspection tasks is developed. The camera is being fixed to the robot. The robot captures pictures of the transmission line at regular intervals of time and distance and transmits them to the control unit. A current sensor is placed so as to find the current that is being passing through the lines.

1.2 Problems of deterioration in transmission lines and their symptoms:

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

1.3Damage to the insulators:

The insulators are affected by impact, weathering, cyclic mechanical and thermal loading, electro-thermal causes, flexure and torsion, ionic motion, cement growth, and corrosion. Temperature difference between hot sunny days and freezing cold nights as well as the heats generated by fault current arcs cause thermal cycling, which produce micro-cracks and allows water to penetrate into material. The amount of imposed stress depends on relative expansibility of dielectric, metal fittings, and the cement used to fix the metal fittings of the line to the dielectric. Cement growth, which is mainly caused by delayed hydration of periclase (MgO) as well assulphate related expansion, generates radial cracks in the porcelain insulators' shell and makes them faulty. Contaminants in the atmosphere, such as sea or road salts, can attack both Portland cement itself, or if penetrate into metal parts, can corrode galvanizing surface. Ionic motion caused by electric field makes this situation worse.

1.4 Damage to the 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 the aluminium strands and attack galvanizing protection of the steel. Corrosion of the galvanizing coat exposes steel and aluminium to each other and leads to galvanic corrosion between iron and aluminium. As an anode, aluminium

corrodes rapidly and white powder aluminium hydroxide is produced. Loss of aluminium strands decreases current carrying capacity and mechanical strength of the line.
In addition to corrosion, wind induced vibrations can make severe mechanical damage to the conductors due to generating cyclic mechanical load. The wind flow creates vortices downstream when it passes the line. These vortices produce fluctuating lift and drag force scausing aeolian vibrations with frequencies from 10-30 Hz and amplitudes of the order of diameter of the conductor. In bundled conductors, the wind also induces sub-conductor oscillations, which can cause fretting of the aluminium strands near the clamps. The fretting reduces the fatigue strength of the line and speeds up the failure process.

1.5 Symptoms of the transmission line damage and detection methods:

Damage to the line can be detected through investigation of their symptoms. Most of the line problems produce unusual partial discharges. Whenever the electric field intensity on the line surface exceeds the breakdown strength of air, electrons in the air around the conductor ionize the gas molecules and partial discharges, namely corona effects, occur. High frequency partial discharges produce radio noise in ultra-high frequency range, as well as audible noise in ultra-sonic range. In addition to noise, discharges send a current to the line. This current can also be used to detect faults. Depending on the weather, age of the line, problem conditions, and other factors, the level of discharge can also be different. Abnormal temperature is another symptom, which can be used to identify defects on the transmission lines.

Based on aforementioned major symptoms, following techniques are mainly used for detecting faults in the transmission lines:

1. Ultrasonic detection
2. Measurement of corona pulse current inconsistency
3. Partial discharge detector
4. Infrared inspection of overhead transmission lines
5. Radio noise detection system
6. Solar-blind power line inspection system (through detecting UV)
7. Corona current monitor for high voltage power lines
8. Fiber optic application to transmission line inspection
9. Audible noise meters
10. Field testing of insulators

2. ENVIRONMENT OF POWER TRANSMISSION LINES

A 500KV torsion tower is shown in Fig. The inspection robot with wheel-driven can crawl along the overhead ground wires. The subsidiary equipment's of the overhead ground wires will act as obstacles to block its way. A navigation system is needed to recognize and locate the obstacles with its sensors. There are three typical obstacles attached to the overhead ground wires and 550KV power tower. The first type of obstacle is called counter weight which is the greatest quantity among the obstacle. The second type of obstacle is anchor tower which is easy for the inspection rotor to cross. The third type of obstacle is called torsion tower which is difficult for the inspection rotor to cross. Each type of obstacle has different spatial structure. Therefore, the inspection robot should walk with the different motion sequence according to the different obstacle.

2.1 Kinematics tasks:

The typical structure of the transmission phase line, includes suspension and tensioning angle towers, phase lines and accessories (dampers, suspension or tensioning line clamp, insulator chains, etc.). Taking the phase line as its moving path, the prototype has to carry out three kinematics tasks as follows:

a) Moving along the no-obstacle segment of the phase line:
b) Overcoming the obstacles along the phase line including the suspension/tensioning tower, dampers, clamps, and insulator chains, etc.:
c) Varying moving paths between phase line and jumper line.

2.2 Flexible obstructive inspection moving path:

The flexibility of the transmission line is very high, because the span between two adjacent towers is usually as much as hundreds of even more than one thousand meters, and the sagis scores of meters as while. Moreover, the environmental wind loads may excite Aeolian vibration, or galloping in the winter, of which the vibration and force can be transferred to the robot. On the other hand, when the robot overcomes obstacles or change moving paths, it has to adjust postures and thus produces unbalanced force. The coupling of the robot and overhead line will force the robot to vibrate and thus decreases its performance.

3.Mechanical Configurations:

The robot is in the form of a car which moves overhead of the transmission lines with the help of a rope. The robot balances with three wheels and moves on the rope above. Proper insulation is provided for the robot so that there is no problem for the robot to travel along the transmission line. The robot moves slowly on the transmission line.

3.1Action programming for damper-overcoming:

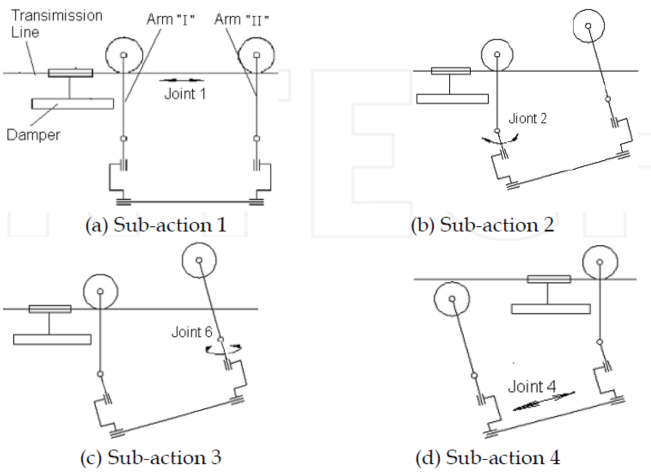


Fig (1)

(a)-(d). Sub-action 2, 3, and 4 are basic for obstacles-overcoming.

(a) Sub-action 1: Two wheels roll along the transmission line with two arms are parallel suspending on the line.
(b) Sub-action 2: Arm I (or Arm II) end manipulator clamps the line, while the robot rotates with Joint 2 (or Joint 6) to lift/descend the robot body by 30˚.
(c) Sub-action 3: Arm I (or Arm II) end manipulator clamps the line, while another arm rotates with the axis of Joint 5 (or Joint 3) by 180˚.
(d) Sub-action 4: Arm I (or Arm II) end manipulator clamps line, while another armtranslates along Joint 4 the slide rail to transpose two arms.

4. Block Diagram:

4.1 Transmission Block:

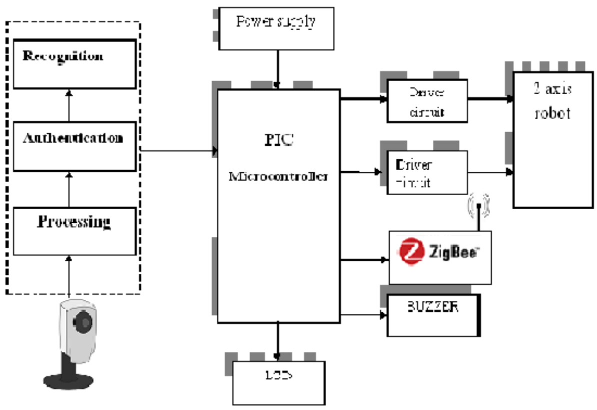
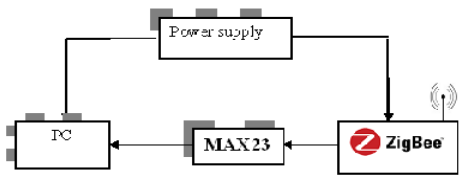


Fig (2) Transmission Block

4.2 Monitoring section:



Fig(3) Monitoring Section

4.3 Description:

The images that are captured from the camera are received by the controller through the Zigbee protocol. Once the images are received they have to be compared. At first the images are processed by Digital Image Processing the unwanted noises are being removed. Then the images are authenticated and recognized. The original images are saved in the monitoring section. When the captured images are received they are compared. In case if any defects are found then the buzzer indicates with an alarm and the LCD display notifies a message saying defect is found and the process is going on.

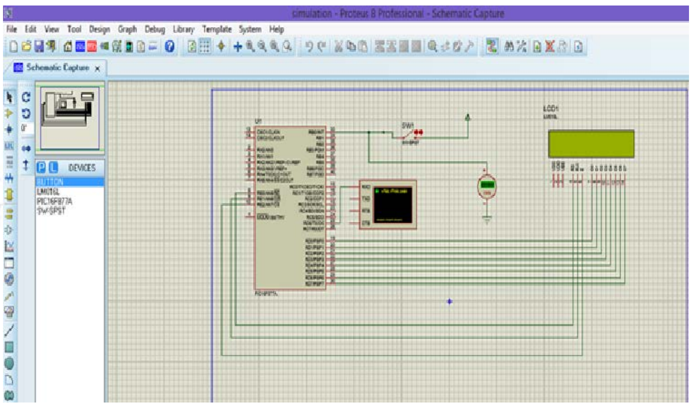
5. Function:

The inspection robot is composed of mechanism, power on-line supply, sensor and obstacles detection, navigation, image scanning and detection, data wireless transceiver, and control system. The self-governing on robot's obstacle-overcoming is realized by means of autonomous navigation of multiple electromagnetic sensors andmachine visual hybrid servo. Magnetic energy of transmission conductor is converted intoelectric energy for power supply. Therefore, the robot can fulfill six basic functions asfollows: (1) full path moving along 220kV phase line with obstacles, (2) online power supply and monitoring, (3) navigation including obstacles' detecting, identifying and location, (4)visible light/infrared image scanning and detection, (5) wireless communication, (6) robotself-postion detection, grasping force detection, and motions programming.

6.Simulation:

The simulation was done in Proteus software. A sample of wire was taken as a switch. When the switch is closed it is taking as there is no problem on the transmission line and when the switch is open there is a defect on the line.

This process is displayed on the LCD screen as "Inspecting" and when a defect is found it is displayed as "Defect Found". Through Zigbee protocol we have displayed the message on the virtual terminal also. The current and the voltage are also found.



Fig(4) Simulation Output

7.MATLAB:

MATLAB (matrix laboratory) is a multi-paradigm numeric computing environment and fourth-generation programming languag Developed by MathWorks, MATLAB allows matrix manipulation plotting of functions and data, implementation of algorithms, creatio of user interfaces, and interfacing with programs written in othe languages, including C, C++, Java, Fortran and Python.
The process is shown below:

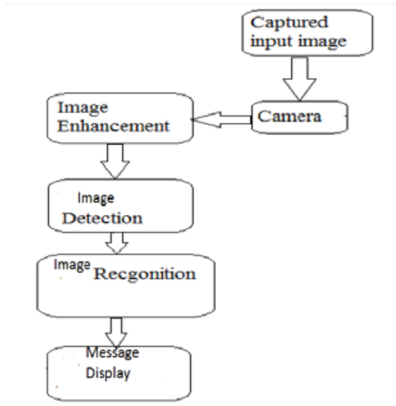


Fig (5) Process Block Diagram

- The image is captured first.
- It is then sent for image enhancement.
- Thirdly the image is detected comparing the old images.
- Once the image is recognized then the display message is given.

8. OVERALL FLOW DIAGRAM

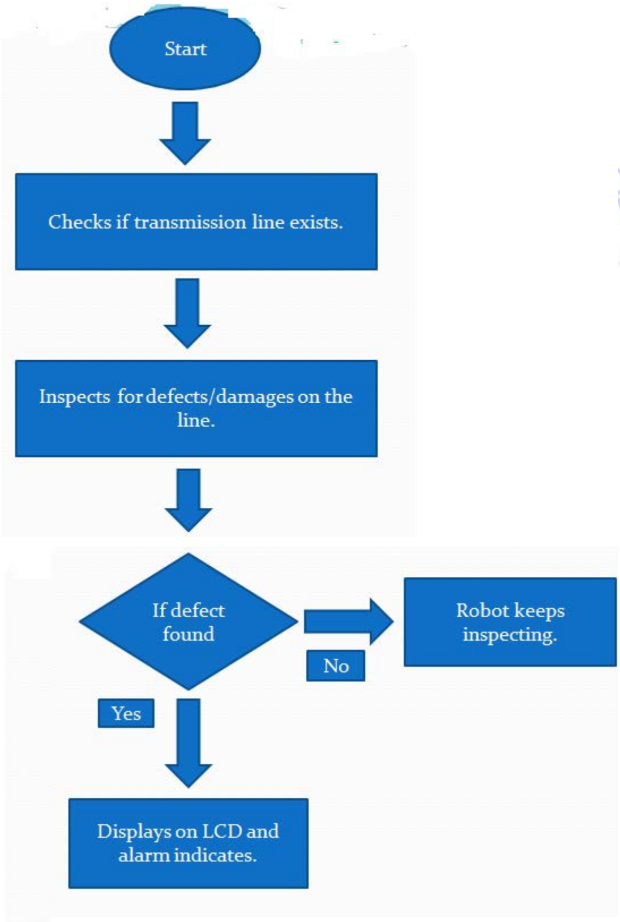


Fig (6)

- The robot first checks if the transmission line exists.
- Inspects for defects and damages on the line.
- In case if any defect is found the alarm indicates and a display message is provided.
- Else the robot keeps inspecting.

9. Conclusions:

This paper presents inspection of the transmission lines that runs across the cities. The inspection robot consists of wheels and camera so that it moves overhead of the transmission line to capture images. Proteus is used for simulation. The coding for the controller is done using MPLAB IDE. The image processing is done with MATLAB. The paper explains that this method would be appropriate for the inspection of transmission lines.

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