DESIGN AND DEVELOPMENT OF A FLYING OBJECT FOR INSPECTION AND CLEANING OF DISTRIBUTION POWER LINES IN SRI LANKA

KKV Gunawardana[1], U Hemapala[2] and B Jayasekara[3]
[1]Sri Lanka Air Force Base, Ratmalana, Sri Lanka
[2,3]Department of Electrical Engineering, University of Moratuwa, Sri Lanka
[1]*kalanagunawardana123@gmail.com*

Abstract - Inspection, detection and cleaning are essential for the maintenance of distribution power lines (DPL). Developed countries use unmanned automated vehicles (UAVs) for this purpose. Helicopter usage is efficient but costly and ineffective for developing countries. Manual inspection and cleaning is the current method used in Sri Lanka. Most research on UAVs in the developing world are at experimental level; practical appliances have been slightly neglected. It is possible to use UAVs to inspect, detect and rectify the issues occur in DPLs in Sri Lanka. This can reduce costs, risks and logistic problems of manual inspection and cleaning. Aim of this project was to design and develop an Unmanned Automated Flying Object (with a Robot Arm) and test its' applicability in inspection and cleaning of DPLs in Sri Lankan context. This paper describes the design and preliminary test results of flying, video transmitting and receiving performances of the Quadcopter. Design of the system architecture of the Quadcopter encompasses a flight control system, Xbee module, inspection camera and a robot arm. The flight control system was tested by practical demonstration. Flying route was recorded from the ground station. The inspection system was tested by visual images transmitted to the ground station. The Quadcopter demonstrated safe flying. Minor errors caused in inspection and detecting may be due to sudden winds, poor GPS signals or electromagnetic interference. Testing of the robot arm is still underway. Upon completion of the experiment this Quadcopter can be used in Sri Lanka to detect contaminations and clean DPLs.

Keywords - Quadcopter, distribution power lines (DPL), Inspection

I. INTRODUCTION

Electric power distribution is the final stage in the delivery of electric energy to the consumers. Transmission of electrical energy along large distances is via overhead power lines; heather to referred as the 'distribution power lines' (DPL). Since most of the insulation is provided by air, overhead power lines are generally the lowest-cost method of transmission for large quantities of electric energy.

The demand for electricity in Sri Lanka had risen due to the country's sustained economic growth. There is a growth in the development of the power transmission and distribution projects island wide (Shimomura et al., 2005). All DPLs should be inspected after construction, before energizing the line and throughout the maintenance process. Maintenance of DPLs has become an important issue because too much investment had been put into the power generation sector (Shimomura et al., 2005). It seems maintenance sector has lagged markedly causing various problems such as insufficient capacities in transmission lines, voltage drops and electrical transmission losses.

In spite of frequent maintenance the DPLs often get contaminated with natural causes and human activities. For example branches of the trees, bushing, bird nesting, animal collisions, kites and other objects. Frequent power outages due to salt contamination on DPLs are common in coastal areas; especially in Puttalam, Mannar and Jaffna areas (Wijayathilaka, 2014). Birds cause damage and disruptions in many ways. They build nests on transmission poles, sit on the lines causing long term accumulation of

contaminations by bird droppings, collide with power lines and damage facilities causing much inconvenience in maintenance. On DPLs overhead ground wires are often smaller, and so are more likely to cause bird collisions.

Inspection, detection and cleaning are mandatory components of maintenance of DPLs. Manual inspection and cleaning of DPLs is the only method used currently in Sri Lanka. Wijayathilaka, (2014) stated salt contaminations are flushed away from the insulator surface naturally during the rainy season but not up to the sufficient level as most of the coastal areas in Sri Lanka are dry throughout the year. The presently adopting method is wiping out the insulator surface by hand and wash insulators with mild water (with low conductivity) while interrupting the feeder supply. Manual inspection of tree branches and bushes on DPLs from ground is difficult and ineffective. Removal is currently done by the municipalities using tree trim crews. Manual inspection and cleaning of DPLs is difficult, costly, inefficient and time consuming activity. This requires more man power and it carries huge risk for the maintenance crew. Therefore it is timely important to introduce an alternative way that ease the maintenance of DPLs.

Most of the developed countries use robots, helicopters or unmanned automated vehicles (UAVs) for inspection and cleaning of DPLs (Ceron et al., 2014; Li et al. 2013; Wang et al., 2010; Jones, 2005). There are various types of UAVs used in the field, to name some rotorcrafts and unmanned automated aircrafts. Helicopter usage is costly (Wang et al., 2010), may not be effective and affordable for a developing country like Sri Lanka. But instead this can be carried out using UAVs at a very low cost in most of the situations.

Use of UAVs in DPL maintenance is a novel concept in developing countries in the world. At experimental level popular focus is on design, control, runtime and stability of UAVs (Wang et al., 2010; Li et al. 2013) but the practical appliances of these have been slightly neglected. UAVs are not used within the current system in Sri Lanka. However it is possible to use such method for inspection, detection and rectifying the issues that occur in DPLs. Current study has a significance impact on introducing a new approach that reduce costs, risks and the logistic problems of manual inspection and cleaning of DPLs.

Aim of the main project is to design and develop an unmanned automated flying object (with a robot arm) and to test its' applicability in inspection and cleaning of DPLs in Sri Lankan context. The project is still ongoing, there for this paper only describes the design phase of the model aircraft and preliminary test results of flying, video transmitting and receiving performances of the Quadcopter.

II. METHODOLOGY/ EXPERIMENTAL DESIGN

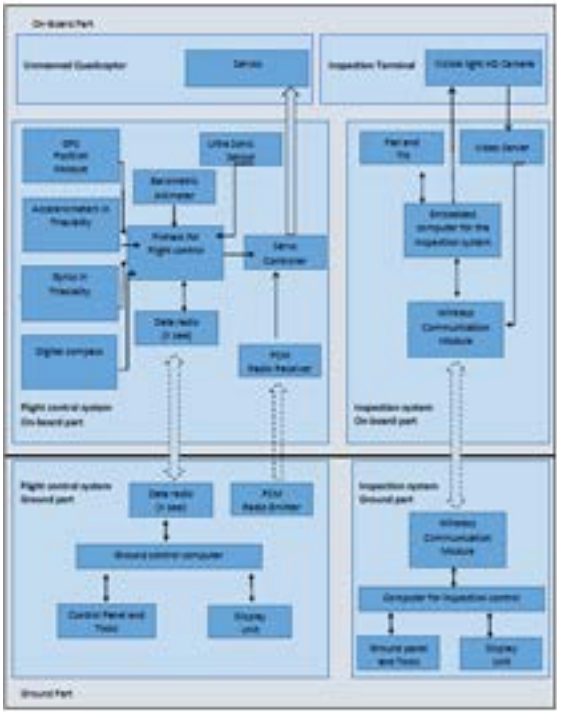

Figure 1: System Architecture of the design (Source: Author)

The model consists of three sub systems; the flight control system, inspection camera system including an Xbee module and a robot arm. The flight system consists of an unmanned flying object (Quadcopter) and a flight control system including an on-board part and a ground part. The computer based on the ground station is for managing flight plans and tasks, manually controlling the Quadcopter and displaying the state parameters of the Quadcopter. Inspection system consists of a HD camera and an Xbee module. The HD camera is used to obtain visible-light images. This can be used to detect visible faults or contaminations on transmission lines. The camera is controlled by the embedded computer at the ground

Figure 2: The model aircraft (Quadcopter)

station. The visible-light camera produces both videos and high resolution still images. The videos acquired by the camera are directly transmitted to the ground through the wireless communication modules. The Xbee module increases the reliability of the communication between the aircraft and the ground station. Videos are processed and then displayed on the computer screen. The still images are saved in the storage unit. Figure 01 illustrates the detailed system architecture of the design.

III. EXPERIMENTAL RESULTS AND DISCUSSION

The model aircraft was developed and installed a video data link, HD camera and the Xbee module on it. A practical demonstration was conducted to test the flight control system. The aircraft could fly successfully along a 33kV distribution power line. Total flying distance was about 2 km. Flying route was recorded from the ground station. Practicability of the inspection system was tested by the visual images transmitted to the ground station from the Quadcopter. Figure 2 and 3 show the Quadcopter and the interface of flight control system.

In many developing countries the inspection and cleaning of distribution power lines is mainly carried out manually whereas the developed countries use helicopters and UAVs (Wang et al., 2010). Current project is a novel concept to design and develop a Quadcopter with abilities to inspect, detect and rectify the contamination of DPLs.

Figure 3: The interface of flight control system

This Quadcopter is controlled by a radio- transmitter sending signals to a receiver in the model which in turn actuates servos which manipulate the model's flight controls in a similar manner to a full sized aircraft. We used a flight controlling computers to fly the aircraft autonomously and to stabilize the aircraft. Vision information is a good means of inspection and detecting the errors on DPLs (Wang et al., 2010). There's still room for further improvement of the quality of visual information if used a thermal camera (Wang et al., 2010). Austin and Earp (2004) used a TV camera with 10:1 lens with a thermal camera in their unmanned helicopter in order obtain a better inspection. Design and development of the robot arm is still under way. The experiment will continue to test the practicability of visual system and the robot arm, which is our future work. The project will be completed by September 2018.

IV. CONCLUSION

In conclusion the UAV demonstrated safe flying. Minor errors caused in inspection and detecting may be due to sudden winds, poor GPS signals or electromagnetic interference. Testing of the robot arm is still underway. This UAV can be further improved using a thermal detection camera for thermal detection. Upon completion of the experiment this UAV can be practically used in the current system to detect and clean DPLs in Sri Lanka.

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