# Stringing High Tension Wire in Hilly/River Terrain Using Multiple Drones with Single Control Unit

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***Abstract :*** *Placing high tension wires in hilly areas and across rivers is difficult due to their uneven terrain. The existing technology uses Cranes, Helicopters and some other machines to fix broken cables and place new cables. With the rise in technology and modernization, it becomes important to provide electrical supply to every corner of the world so it is necessary to consider providing a viable solution to the Stringing Problems faced in Hilly/River areas. One of the recent technologies which seems to be a viable solution is Unmanned Aerial Vehicles (UAV). These Unmanned Aerial Vehicles can be fully automated or operated from a single control unit, thereby reducing human labor, cost, and also increases the efficiency of the Stringing Operation.*

***IndexTerms - Stringing Operation, Unmanned Aerial Vehicles, Pylon, Drone, Quad copter, Octocopter, Transmission lines.***

## I. INTRODUCTION

Planning of path of high tension transmission lines necessitates the need to take into account geological, financial, environmental and technological factors that might affect the placing of pylons and high tension cables. Planning of such a path leads to necessity of the transmission line crossing over wet lands, rivers, and hilly areas with significant height difference between pylons which hinders the operations of placing or fixing high tension wires.

Generally, when there is a need to place new power lines or fix old ones,cranes and human labor is used. But in uneven terrains like wet lands and hilly areas, such methods cannot be used. It requires the use of a lot of specialized equipment and a huge deal of human labor which makes the whole operation inefficient and expensive. So it becomes obvious to use the help of airfreight for mounting of cables.

Currently there are two possible methods of stringing using airfreight – by unmanned aerial vehicles (UAV or Drones) or by helicopters. Amongst these two methods, Stringing operation using drones are cheaper and more precise whereas use of helicopter requires skilled person to operate and also increases the cost of the operation. The term 'Stringing' refers to the placing and distributing the cables into desired locations such that power engineers can connect them to isolators attached to pylons.

## II. EXISTING METHOD

### 2.1. USE OF WINCHED TRUCKS

In the method shown in fig.1, a winched crane is used to place a new transmission line. This is a tedious process which requires a lot of human effort and is not so precise. At first the wire from the wire drum roll is attached to a pilot wire and is pulled to be placed over a pulley-like arrangement on the pylon using a crane and is tied to a motorized winch on the other side which can then pull the wire through the arrangement. It requires human physical intervention in placing the cable over the pulley-like arrangement risking the safety of the lineman doing the operation. This method is very difficult especially in hilly areas due to hindrance to placing of equipment that needs a solid even ground. It is also difficult to use motorized winches along the slope as the ground could be unstable. This traditional method is expensive and unsafe. Since tensioners and pullers have to be placed in suitable angle in order to perform stringing operation perfectly, airborne methods of stringing becomes a necessity.

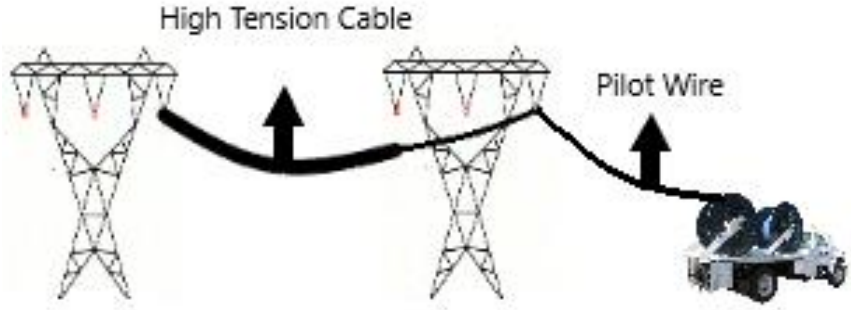


Figure 1 Stringing with Pilot Wire using Winched Truck

### 2.2. Use of Helicopters

Figure 2 Stringing using Helicopter in Hilly area.

In the method shown in fig.2, helicopter is used to place the transmission cable over the pylon in hilly area. The use of airfreight for stringing operation has been a development over the former method of using motorized winch. In this operation, the cable from the wire drum is attached to the helicopter and the helicopter flies over the pylons perfectly to align the cable with the pulley arrangement so as to feed the cable to the pulley and pulls it to the next pylon. This operation requires a very skilled pilot who can hover the helicopter very close to pylon without touching/damaging the pylon with the helicopter. Even though this method is faster compared to the former method, It is very much expensive due to the use of helicopter and has higher risks in damaging the wire or pylon or equipment involved due to the obstacles that might appear during the stringing process such as Low tension lines and telecommunication wires.

## III. Unmanned Aerial Vehicle

The advent of unmanned aerial vehicle technology has opened the gates to many new ventures and has replaced the old methods of many operations. These drones are versatile and precise in any operation that they are assigned. The versatility of drones makes them the perfect choice for applications such as surveillance, transportation and for various military operations. These drones can reach places that are unreachable to humans and also withstand conditions that no human can possibly withstand. Recent developments in UAV technologies have given birth to robust drones which are unshaken by heavy winds and can lift heavy weights. In this paper, we have proposed an application for drones using a single control unit for stringing high tension transmission cables across rivers and in Hilly areas.

### 3.1. Drone Specifications

- 2 × Li-Po GENSACE 6s 10000 mAh + 2 × contingency battery sets to prevent the drone from falling in the case of battery failure.
- Automatic opening and retracting landing gears for safe takeoff and landing of the drone. Parachute arrangement which can deploy when the drone loses vertical height with acceleration higher than 6.5 $m/s^2$
- GPS—Global positioning system is incorporated into drones with a small and compact GPS single chip module which can create waypoints and also track the drone in realtime.
- IMU—Inertial Measurement Unit consist of Magnetometer, accelerometer, gyroscope. These sensors are used for stable operation of the drone. These sensors work together in maintaining balance and also allows the drone to hover at the same place without getting disturbed by the winds.
- Altimeter—Altimeter is basically a Pressure sensor, used to find the altitude. It works on the basic scientific fact that at low altitudes, atmospheric pressure tends to be more and pressure tends to reduce gradually upon increasing the altitude. This pressure difference is measured by this sensor and can be used to determine the altitude of the drone. While stringing in hilly areas using the help of more than one drone, this sensor comes in handy to maintain the tension of the cables between the pylons by appropriately calculating the height.

### 3.2. Simulation

The simulation model of the unmanned aerial vehicle has been built using Proteus ISIS 8.6. This model gives the pulse width modulation(PWM) to the Electronic Speed Controller(ESU) which drives the drone's rotors. It takes height and location as inputs from altimeter and GPS module respectively and uses Atmega328P Microcontroller to process these information and gives PWM as output to the drone's rotors thereby making it to fly to its desired location in space.It also uses an Inertial Measurement Unit(IMU) which comprises of gyroscope, compass and accelerometer to stabilize the movement of the drone and also stay in balance under heavy wind conditions.

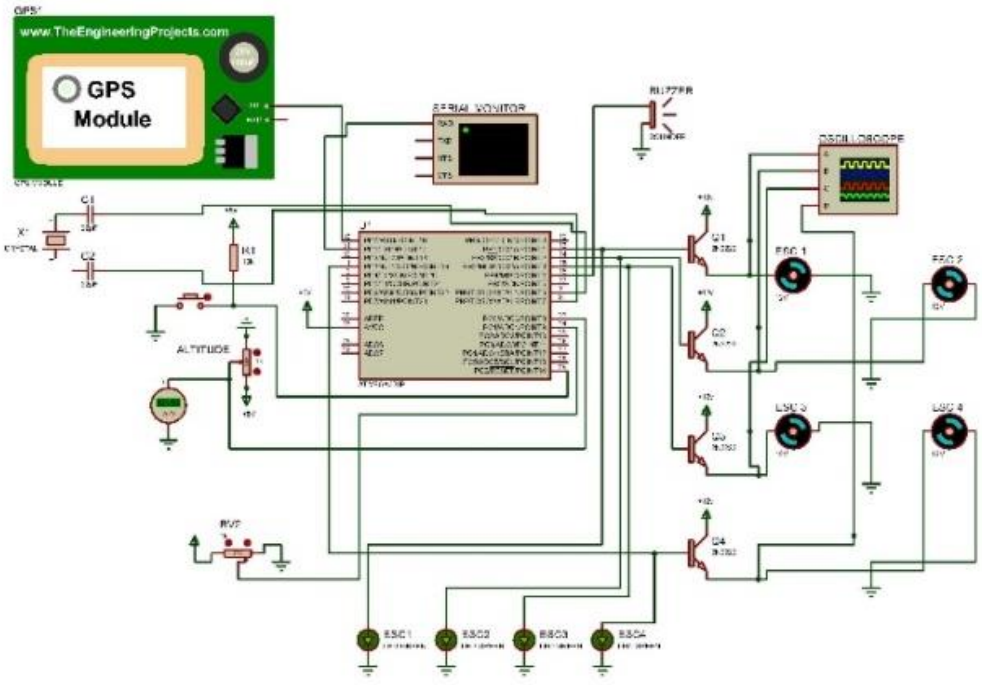


Figure 3 Simulation Model of Drone in PROTEUS ISIS 8.6

### 3.3. Simulation Results

Fig.4 shows the PWM output when the drone is commanded to move upwards carrying the transmission cable. This PWM increases the speed of the drone's rotor till it is able to carry the cable and move up to the desired location.

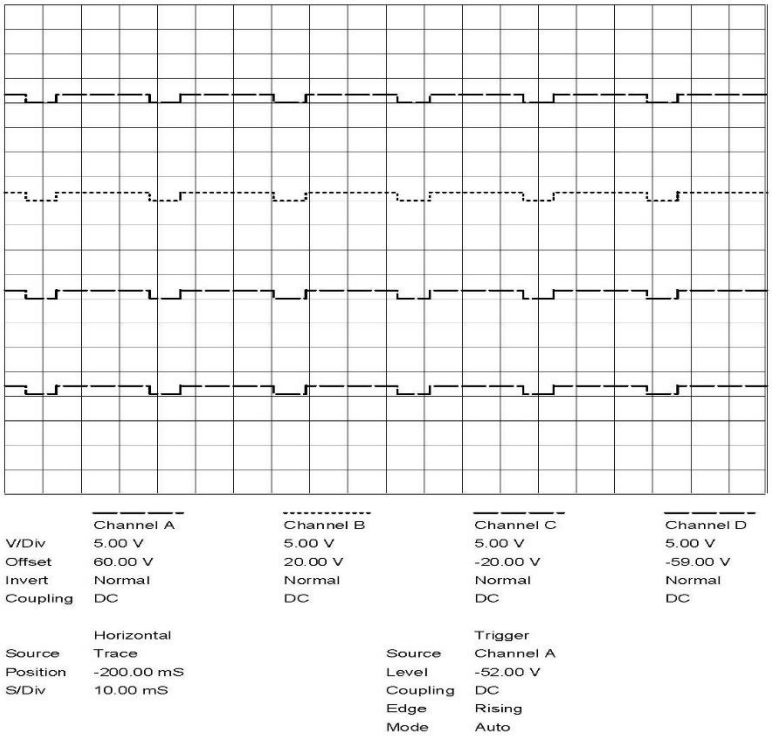


Figure 4 PWM output when drone is rising high

After feeding the cable to the pulley, It gets a different PWM output to reduce the speed of rotor to land on the ground (As shown in Fig.5. The PWM input to the rotor varies instantaneously with respect to the command and also to stabilize the drone in wind. This is achieved by using sensor feedbacks with PID controller which proves to be the most stable controller.

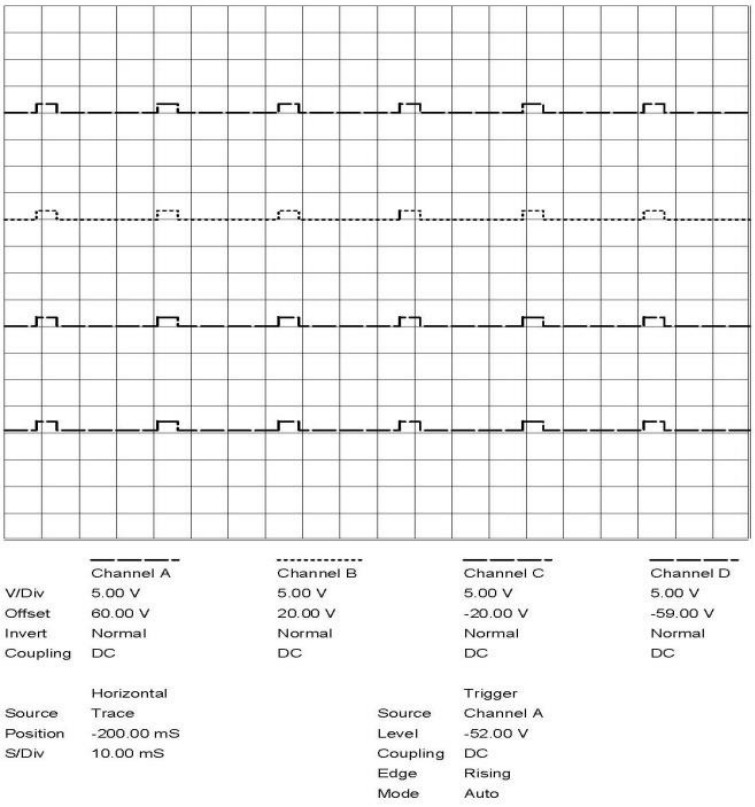


Figure 5 PWM Output when Drone tries to Land

## IV. PROPOSED METHOD

### 4.1. Stringing with Drones

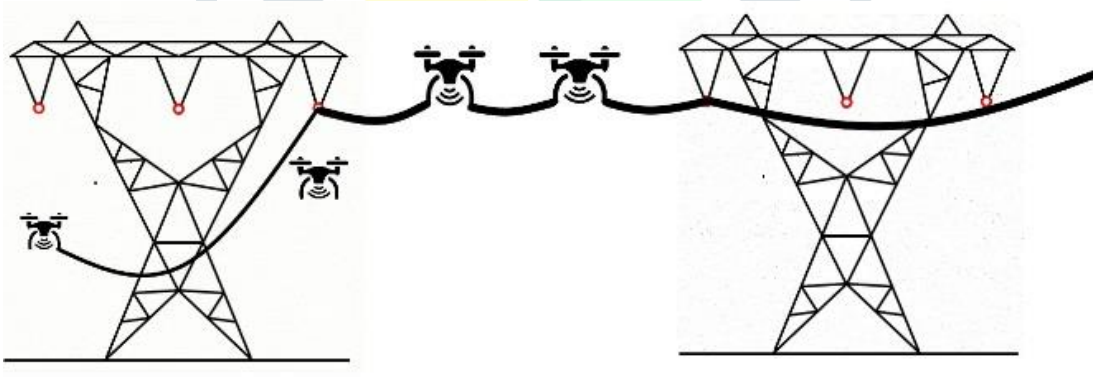

Figure 6 Stringing of high tension cable with multiple Drones

As shown in Fig.6, this paper proposes an application for drones in the field of stringing of transmission cables. This is proposed to be a partially automatic operation with very less need for human effort and also very cost efficient. The detailed specifics of the proposed method of operation will be discussed elaborately in the upcoming sections.

### 4.2. Catalogue of Equipment Required

The following materials and equipment are required for stringing of transmission cables done by airfreight with the help of UAVs.

**Drone** – otherwise known as "Unmanned Aerial Vehicle". They can be remotely controlled or be totally autonomous when coupled with a flight controlling system which has GPS positioning with feedback sensors. Drones have a very unique flight pattern and it can be made in different sizes and with different settings so as to achieve various purposes. For heavy operations like stringing, octo-copters(drones with eight rotors) have to be chosen. These copters can lift heavy loads and fly smoothly irrespective of the weather conditions.

**Pilot rope** – Pre-initial line which is made of polypropylene rope used for conductor stringing under tension.

**Steel drums** – structures made of steel which are used for storage of transmission cables as rolls for easy transportation to the desired location. During the process of unrolling the cable, the drum is coupled with a stationary puller which enables retracting of the cable without tension

**Remote controlled Lock** – This lock arrangement is attached to the drone. It is an electromagnetic lock which releases the transported rope when the operator remotely commands.

**Weight** – An additional ballast of approximate weight of 3Kg – 5 Kg, which can be placed below the point where line is fixed to the drone. It is used for stabilizing the position of the rope and the drone.

**Laborers** – Pilot of the UAV, electricians who climb pylons to place the pulley arrangement and lineman who intercept and fix the cables. These workers communicate using radiophones.

**Generator** – A small generator is necessary to generate the electricity needed to run the other equipment and also to power the drones used for stringing operation.

### 4.3. Controlling Multiple Drones with Single Control Unit

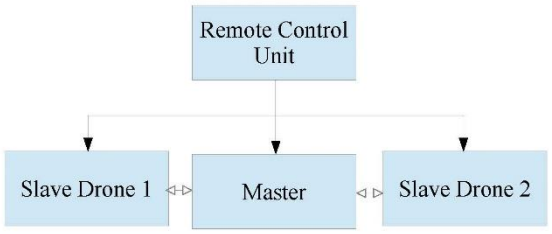


Figure 7 Block diagram for controlling multiple drones with single control unit

Operating multiple drones for a single operation is a tedious process which can't be handled by a single person. So, a control system can be implemented to operate multiple drones using a single control unit in which the operator can select the particular drone or switch control in between drones. The operator can set one drone as a master and others as slave drones such that the master drone controls the slave drones and master drone is controlled by the operator. This chain of command reduces the stress on the operator and increases the efficiency and coordination between drones.

### 4.4. Operation

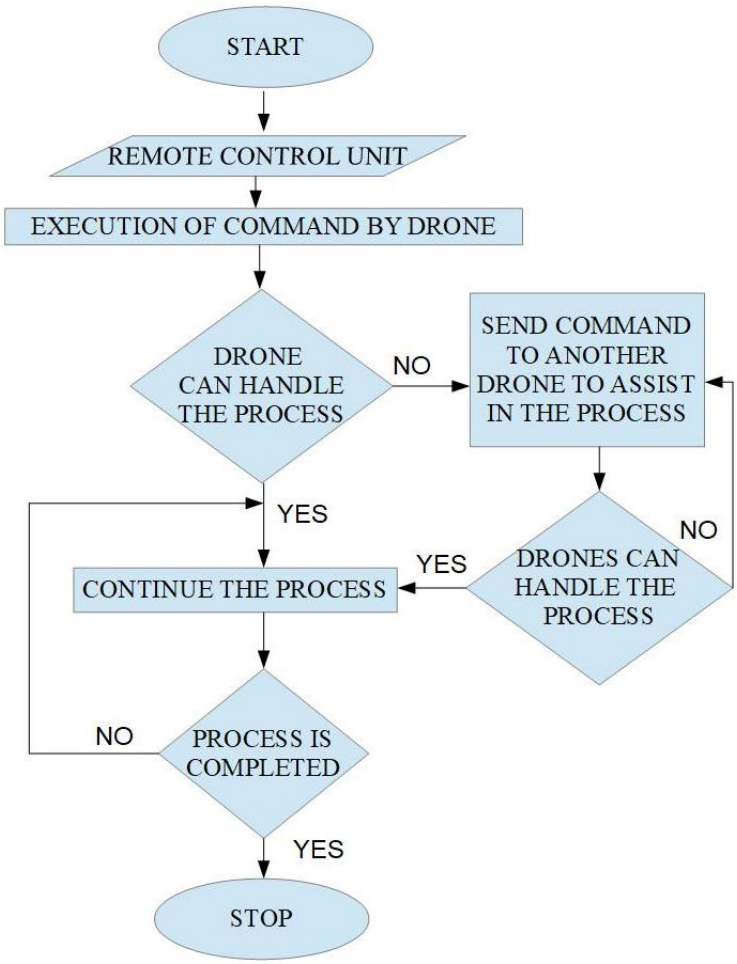


Figure 8 Stringing Operation Work Flow

- First, operation command is sent to the master drone/ the first drone.
- 1st drone pulls the high tension cable across the pylons
- If 1st drone is unable to lift the cable, then it sends the assist signal to the 2nd drone (slave drone).
- 2nd drone comes to assist the 1st drone for pulling the cable.
- If these two drones are unable to lift the cable it requests 3rd drone to assist in the process.
- Master drone gives its exact location to the other drones, these slave drones align themselves in an equal consecutive distance to pull the cable.
- Additionally, Bluetooth/Wi-Fi positioning system can also be implemented in these drones for increasing precision in alignment.

- After placing the cable on the pylon, when the master drone senses the perfect alignment of the cable with the pylon, it gives the command to slaves to release the cable.

## V. COST

Cost is one of the major factors in selecting the methods for stringing operation, according to the financial availability, the method of operation is selected. Renting a helicopter for an hour costs more than Rs.65,000/-. It also has additional charges such as maintenance, pilot, fuel etc., which increases the overall cost of the operation. Whereas using Unmanned Aerial Vehicle removes the need for such charges. Also it is more ecofriendly to use UAV instead of a helicopter.

## VI. CONCLUSION

It becomes obvious to use help of airfreight for stringing operations especially when it comes to uneven terrains such as across rivers and hilly areas. Amongst the choice of helicopter and drones, it seems more viable to use drones (or multiple drones) considering the cost effectiveness of this choice. Though helicopters can lift very heavy weights, new models of drones prove that they can lift heavy loads too. Even when a single drone fails to lift a cable, it can co-operate with other drones to finish its job. Moreover, the drones can not only be used for fixing of these transmission cables, they can also be used for supervision, to detect the location of fault/breakage and to supply tools required by the lineman working in the pylon.

To sum it all up, there are numerous factors to be considered before employing any method to stringing operation in difficult terrains. In most of the cases, it is most beneficial to use drones as it will be at least twice as cheaper and also a safer choice than other methods. The commencement of the operation must be only after the proper investigation of the situation and planning the operation thoroughly. The weather parameters have to be seriously considered and risk analysis must be done before commencing the operation. In an overview, Drones seems to be a more reliable, robust alternative to other methods of stringing and also eliminates the need of deforestation in some areas that might be obstacles to other methods

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