Study Committee A3

Transmission and Distribution Equipment

Paper 10105_2022

RAPID AIS UAV PD SURVEYS USING A UAV

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Elimpus Ltd[1], National Grid[2], UK

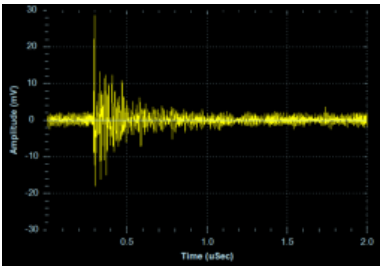
Motivation

- Disruptive failures have been preceded by significant radio frequency (RF) emissions.
- RF-based partial discharge (PD) assessment now policy in many utilities
- Operating hand-held RF spectrum analysers exposes field staff to potential risk and is resource intensive
- A new approach for risk assessing HV equipment is required

Approach

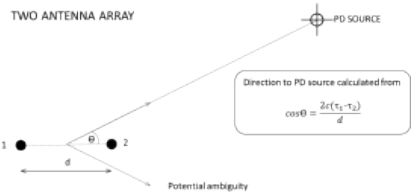
- Combine the maneuverability of a UAV with RF-based PD measurements
- Allows a substation to be surveyed in less time, and with less risk, than using manpower

RF-based PD measurement



- AIS PD creates short duration RF impulses
- Measurement equipment requires bandwidth of, typically, 10 -1000 MHz

Radiometric PD location



- Location of PD source can be calculated using 4 antenna array if timing accuracy < 1ns
- Alternatively the direction to the PD source can be calculated using 2 antenna array, but ambiguity exists
- 2 antenna arrays better suited to UAV

UAV

- UAV previously used for overhead line inspections
- 6 rotors, retractable landing gear
- 1.6 x 1.5 m, 10 kg weight, 5.5 kg maximum payload
- 18 minutes flying time (down to 10% battery) at maximum payload

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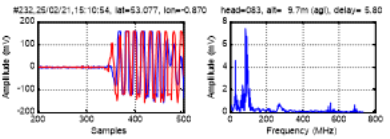
UAV attachment

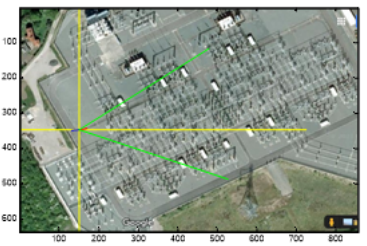
- Bespoke design for UAV – fits on accessory rail
- 1.5 GSps sampling and 900 MHz bandwidth
- Triggered recordings and GPS data saved to SD card
- Lightweight wideband antennas (2)
- Real-time telemetry via Bluetooth
- 1 hour battery run-time
- 1.6 kg weight, centre of gravity neutral

Test flights

- 29 test flights from 3 separate locations
- 2 of locations are 400 kV substations
- UAV flown by experienced, utility staff pilot
- PD system operated by experienced engineer
- Confidence in the use of the system increased during testing

Findings





- PD measurement can be made during flight
- Need to avoid positions of high electric field – causes internal PD due to lack of equipotential bonding
- Need to avoid positions of high magnetic field intensity – affects compass of flight controller

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Discussion

- Analysis of data using the desktop application showed that the PD source position is difficult to determine unless the antennas are equidistant from source – '0° position'
- It is easier to locate PD sources from the UAV, than on ground, since the UAV has mostly uninterrupted line of sight
- A substation survey is best completed as series of overlapping squares, e.g. of side length 40m

Future work

- Ultimate aim: to provide completely automated PD survey of a substation including analysis
- This aim must be approached stepwise, the next steps are:
    - Provide automation of PD recording system
    - Programme UAV flight controller to follow prescribed route through substation
    - Identify optimal routes for any specific substation
    - Include phase resolved PD patterns
    - Automate analysis of results to identify HV equipment as the PD source

Conclusion

- RF-based PD detection is feasible from a UAV platform in flight over a transmission substation
- The project demonstrated unambiguous PD location through analysis of flight-recorded data