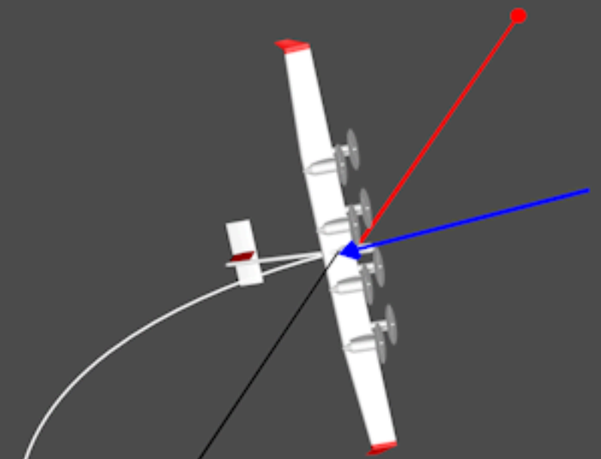
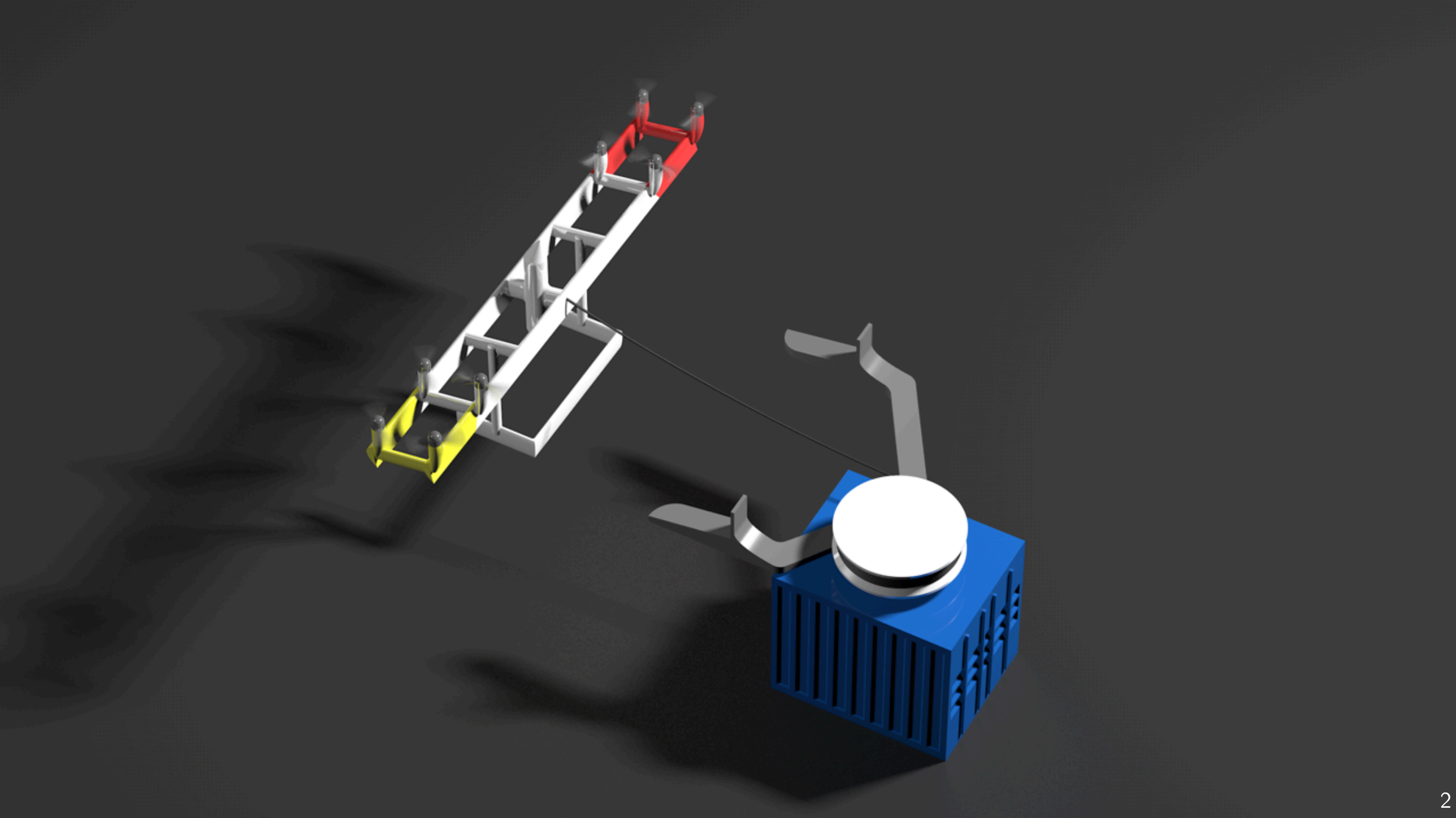
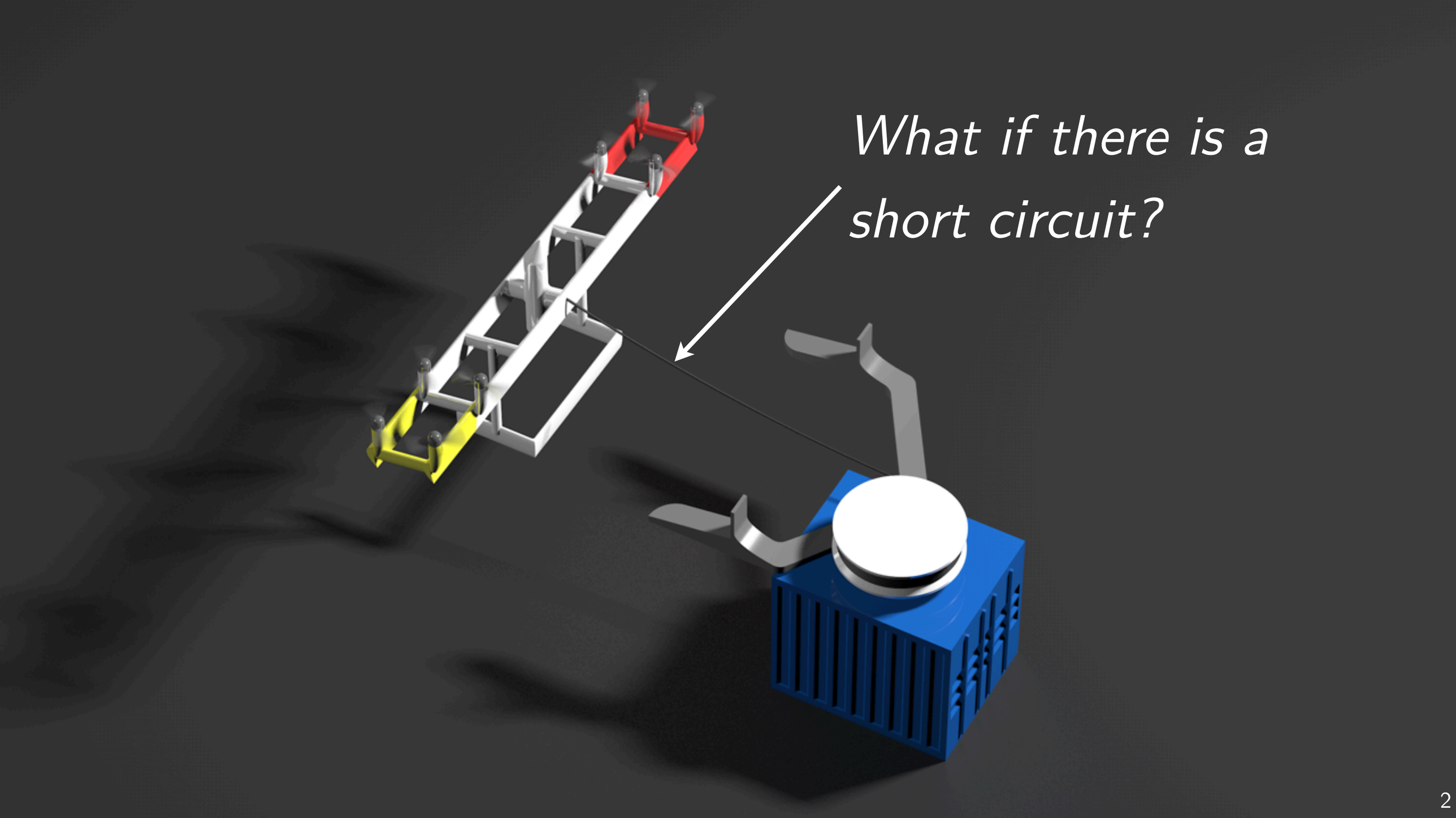
Institute for Electrical Drive Systems and Power Electronics,
Department of Electrical Engineering and Information Technology,
Technische Universität München

Power Electronic Topologies of Drag Power Kites



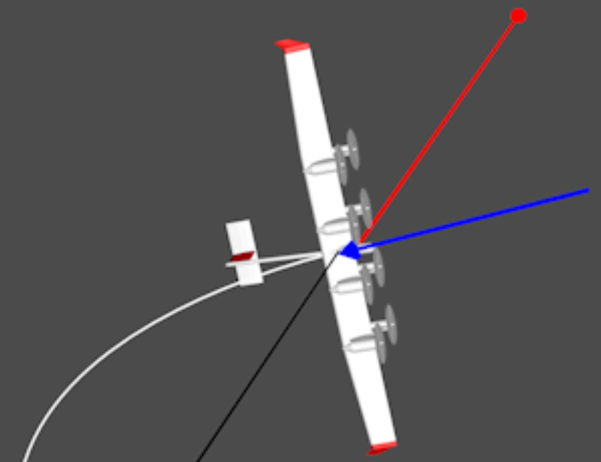
Florian Bauer, Hannes Börngen, Ralph M. Kennel
florian.bauer@tum.de,
October 16th, 2019,
Airborne Wind Energy Conference 2019, Glasgow, UK




What if there is a short circuit?

Outline

1. Requirements
2. Review of Topologies
3. Proposed Topology
4. Conclusions



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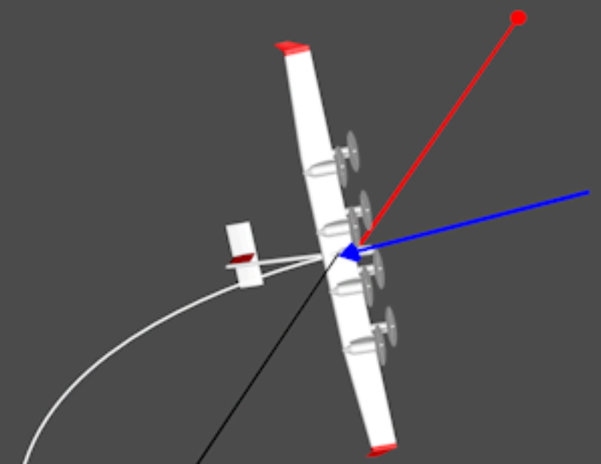

Hard Requirements for the Power Electronics Topology

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A battery on a large-scale kite capable for hovering/ emergency landing is likely unfeasible.

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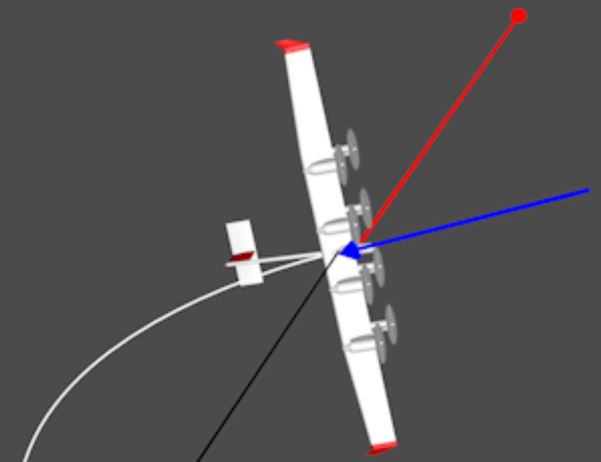

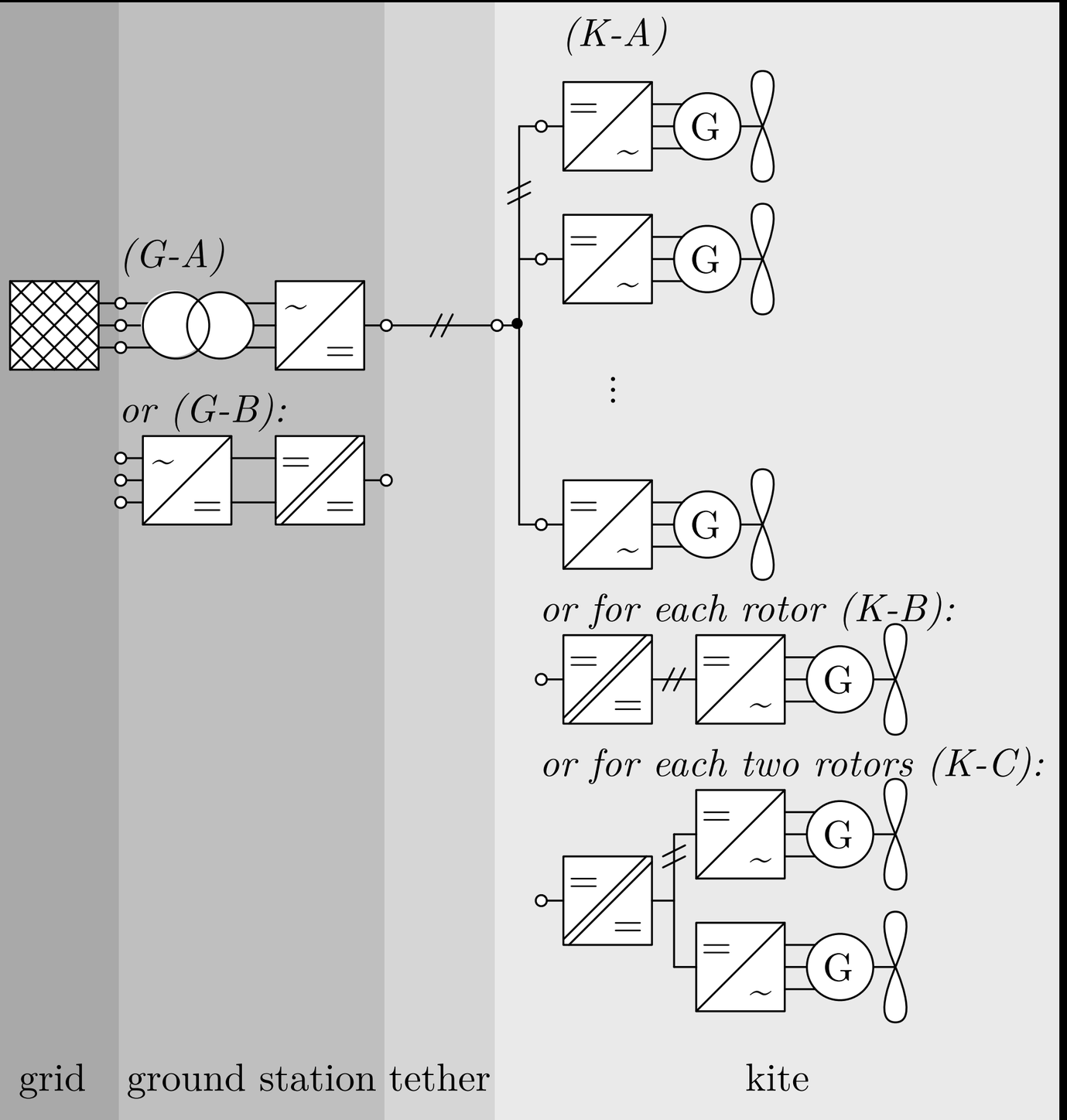

J. W. Kolar, et al.
"Conceptualization and multi-objective optimization of the electric system of an Airborne Wind Turbine".

In: 2011 IEEE International Symposium on Industrial Electronics. June 2011, pp. 32–55. doi: 10.1109/ISIE.2011.5984131.

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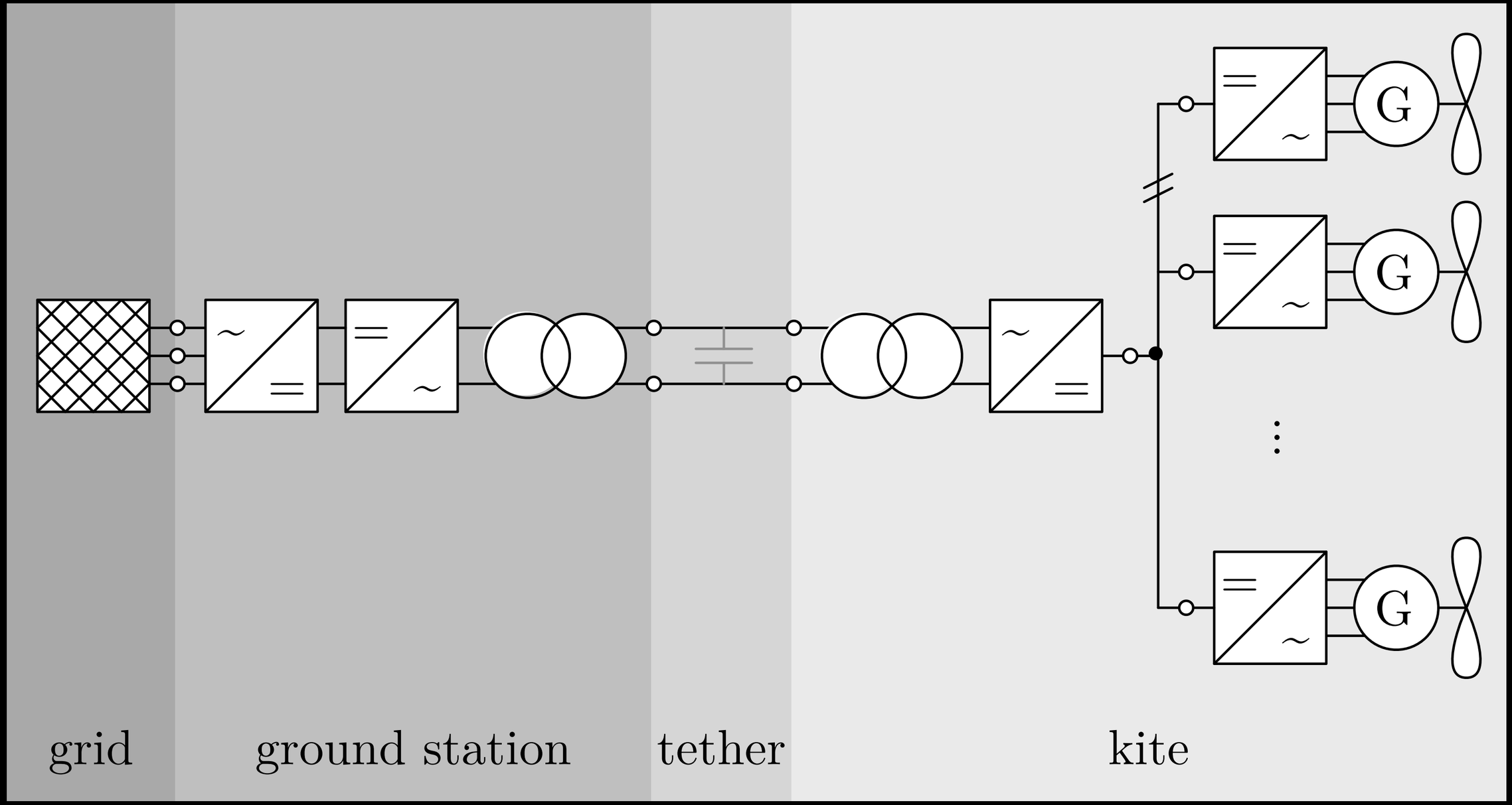

A. Goessling and L.F. Casey. “High frequency bi-directional AC power transmission”.

US Patent 9,151,272. Oct. 2015.

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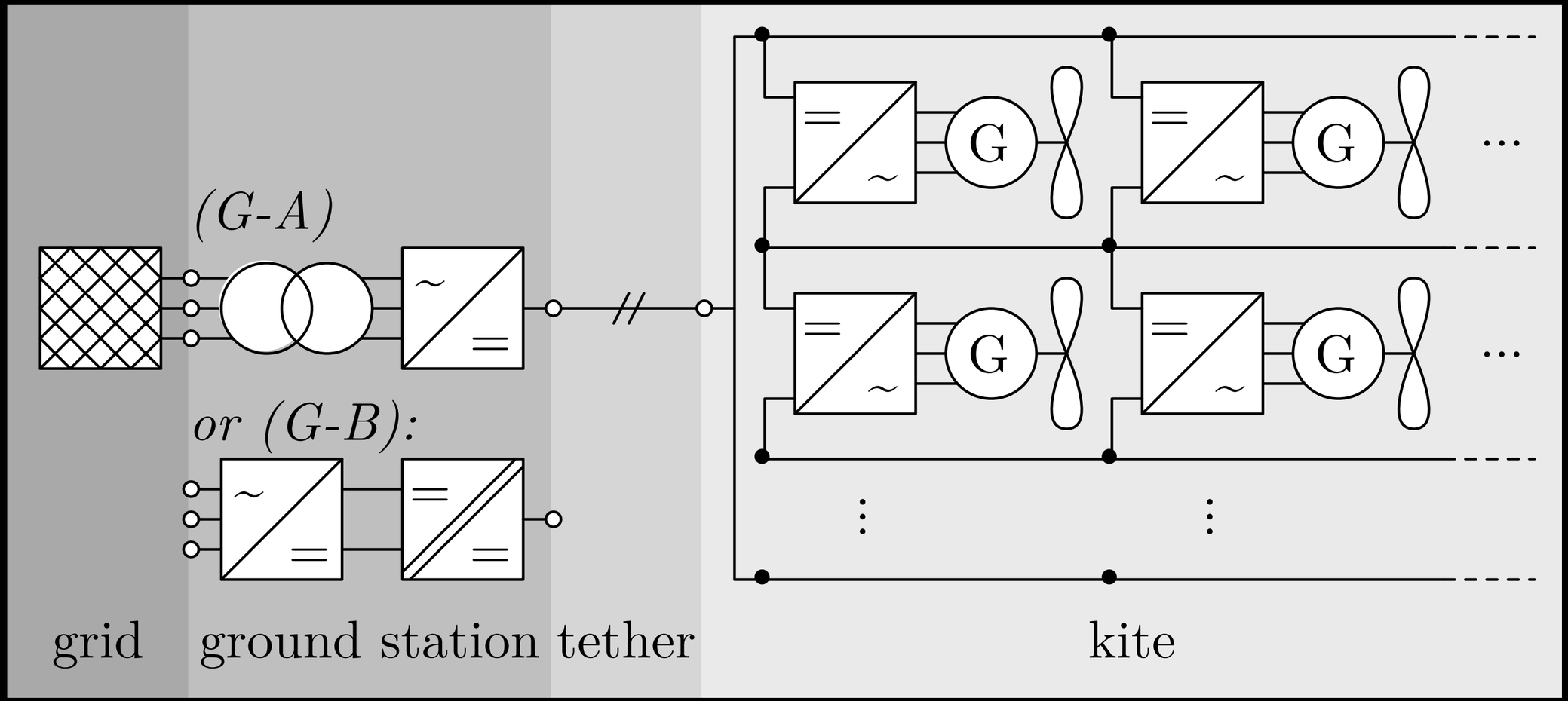

F. Bauer, et al. “Multicopter With Series Connected Propeller Drives”.
In: IEEE Transactions on Control Systems Technology PP.99 (2017). issn: 1063-6536. doi: 10.1109/TCST.2017.2679071.

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US Patent 9,611,835. Apr. 2017.

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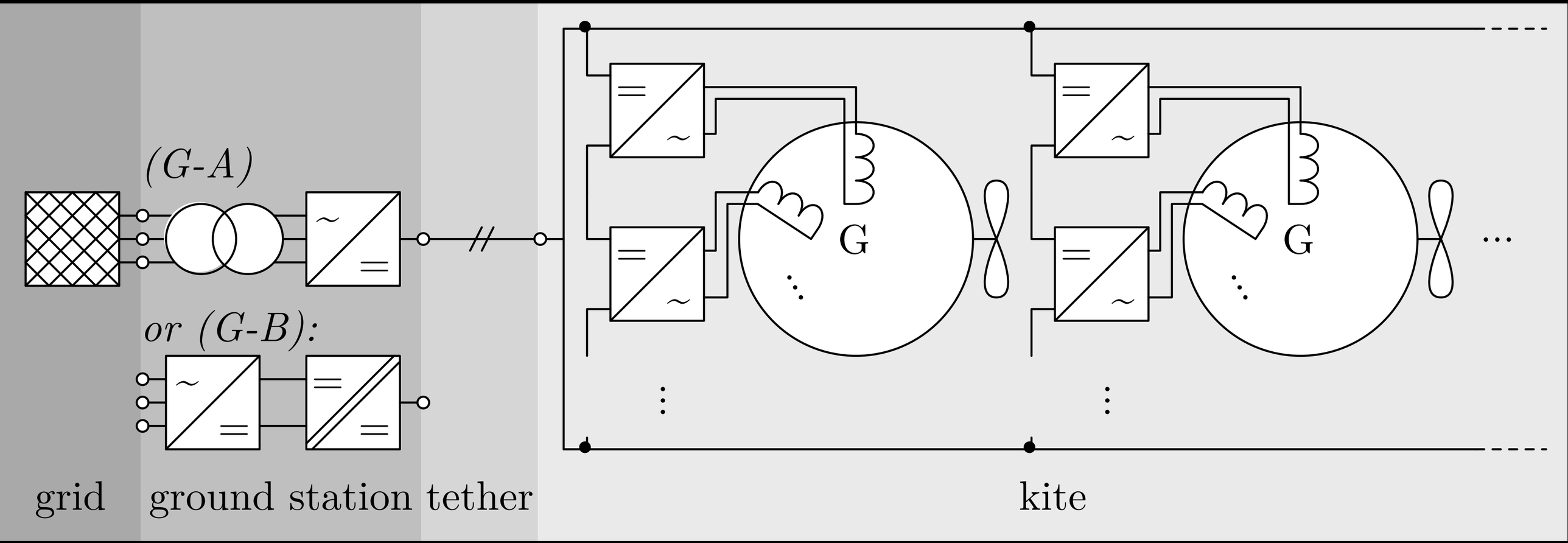

A.D. Goessling and E.H.II. George. “Motor with multi-phase windings and series-stacked inverter”.

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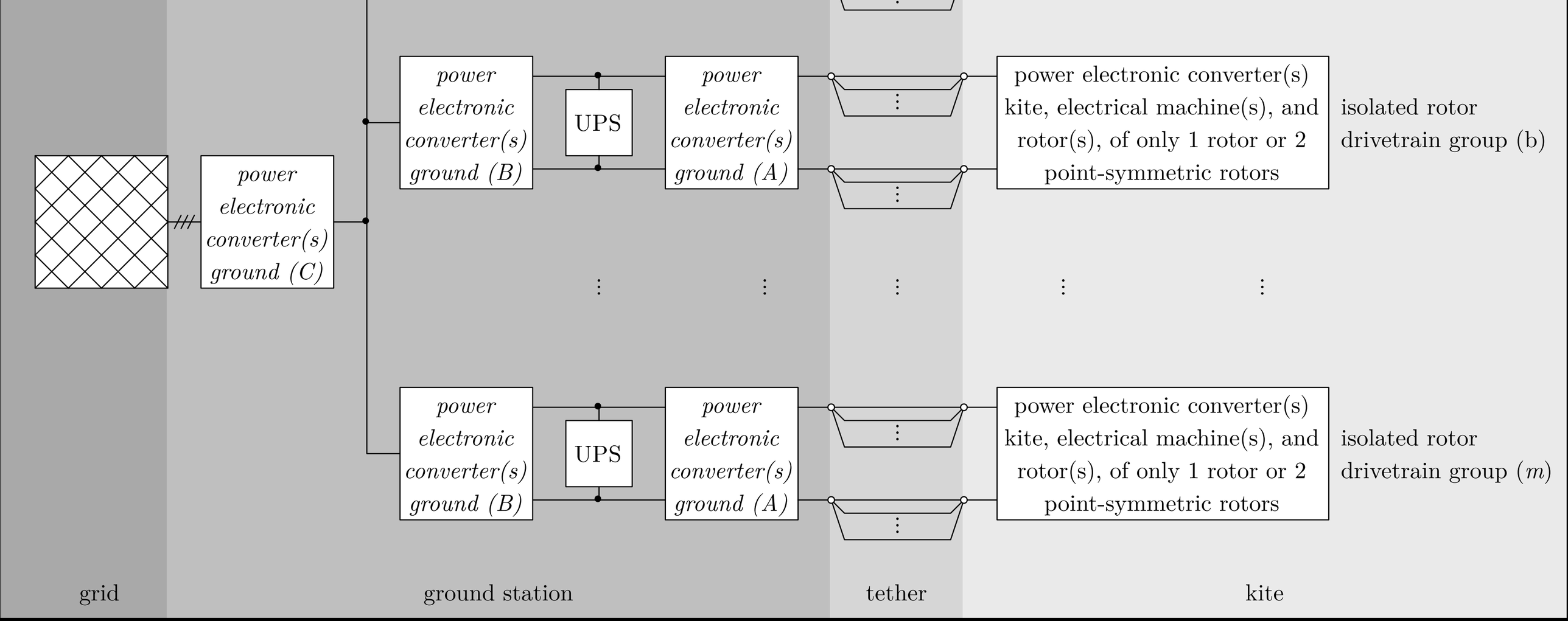
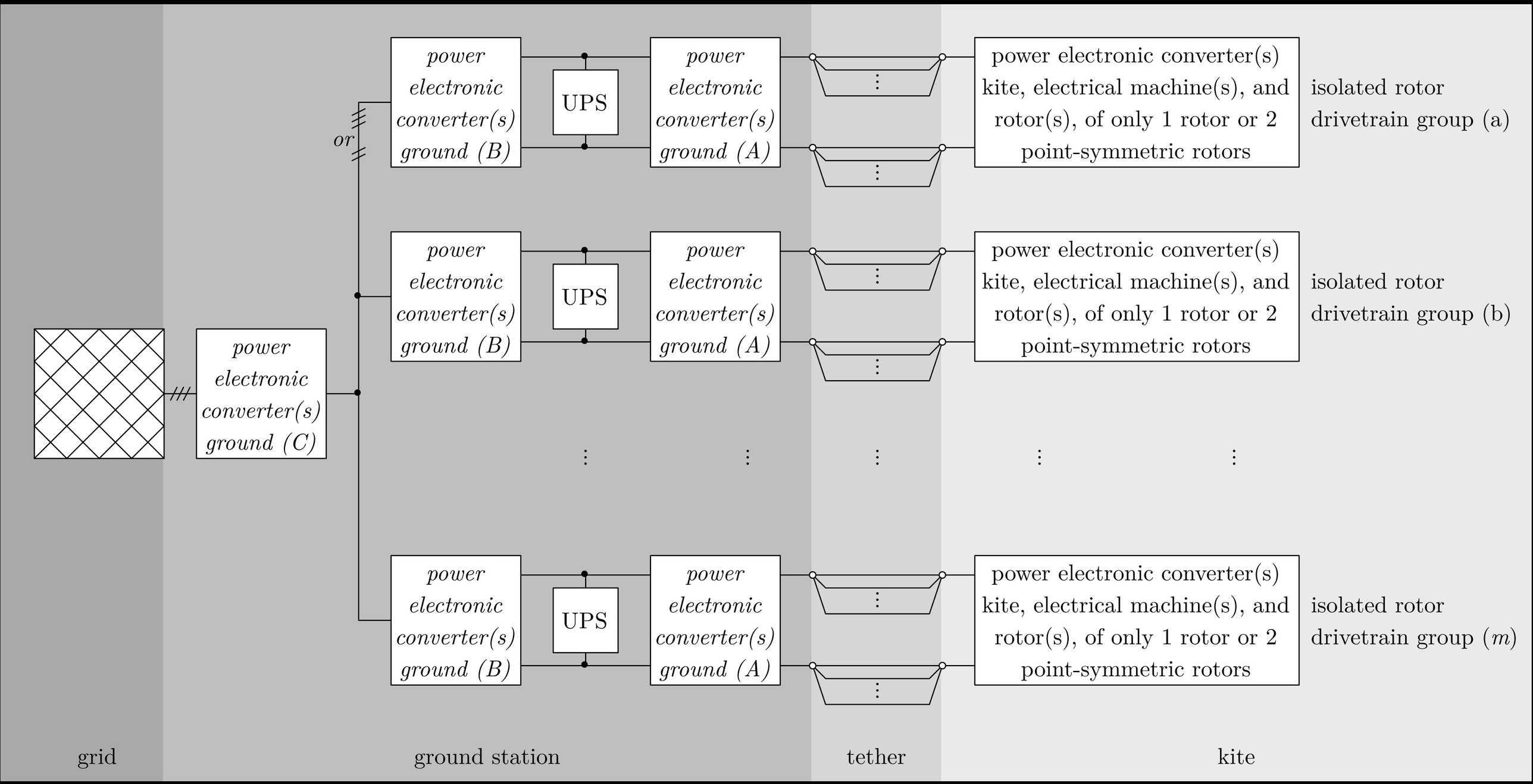


Florian Bauer and Ralph M. Kennel. "Fault Tolerant Power Electronic System for Drag Power Kites".

In: Hindawi Journal of Renewable Energy (2018). url: https://www.hindawi.com/journals/jre/aip/1306750/ (visited on Feb. 11, 2018).


power electronic converter(s) ground (C)
power electronic converter(s) ground (B)
UPS
power electronic converter(s) ground (A)
or
power electronic converter(s) kite, electrical machine(s), and rotor(s), of only 1 rotor or 2 point-symmetric rotors
isolated rotor drivetrain group (a)
isolated rotor drivetrain group (b)
isolated rotor drivetrain group (m)
grid
ground station
tether
kite

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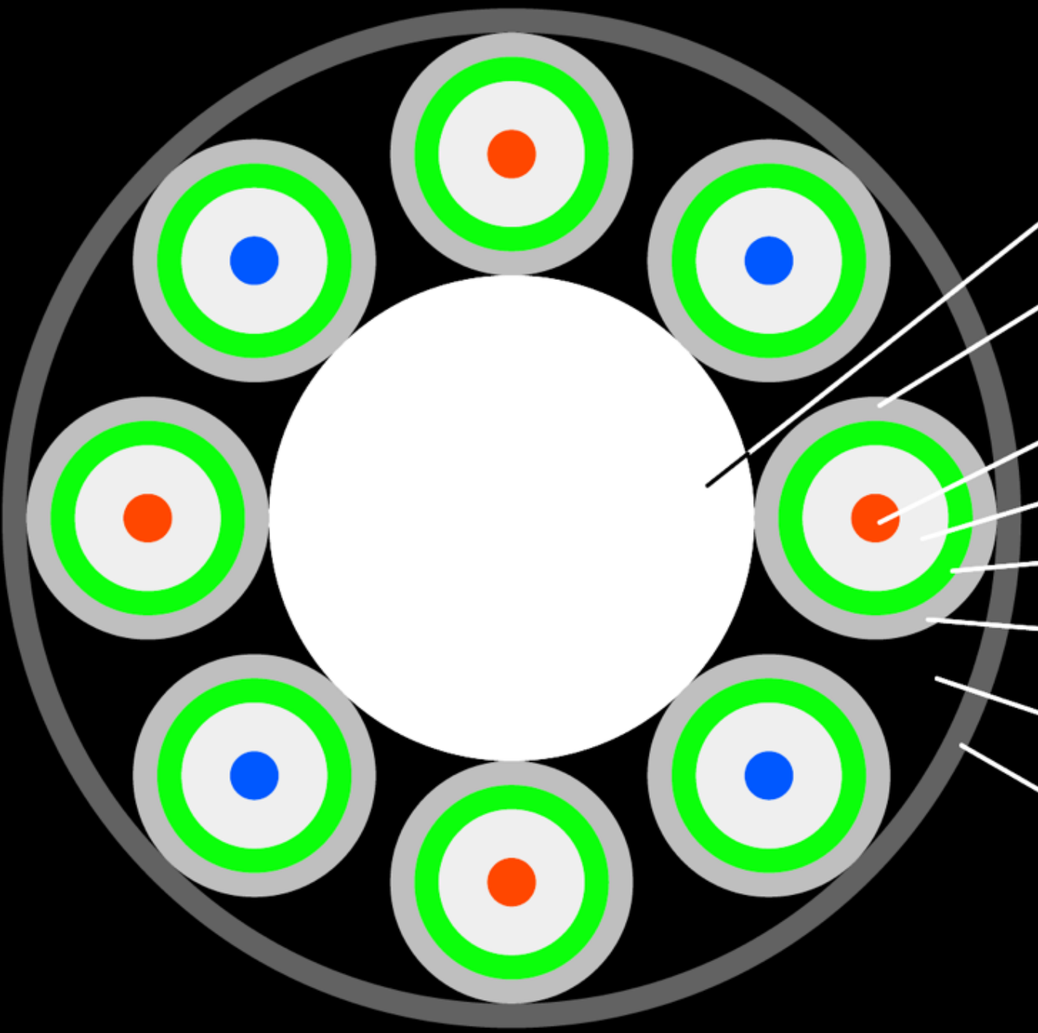
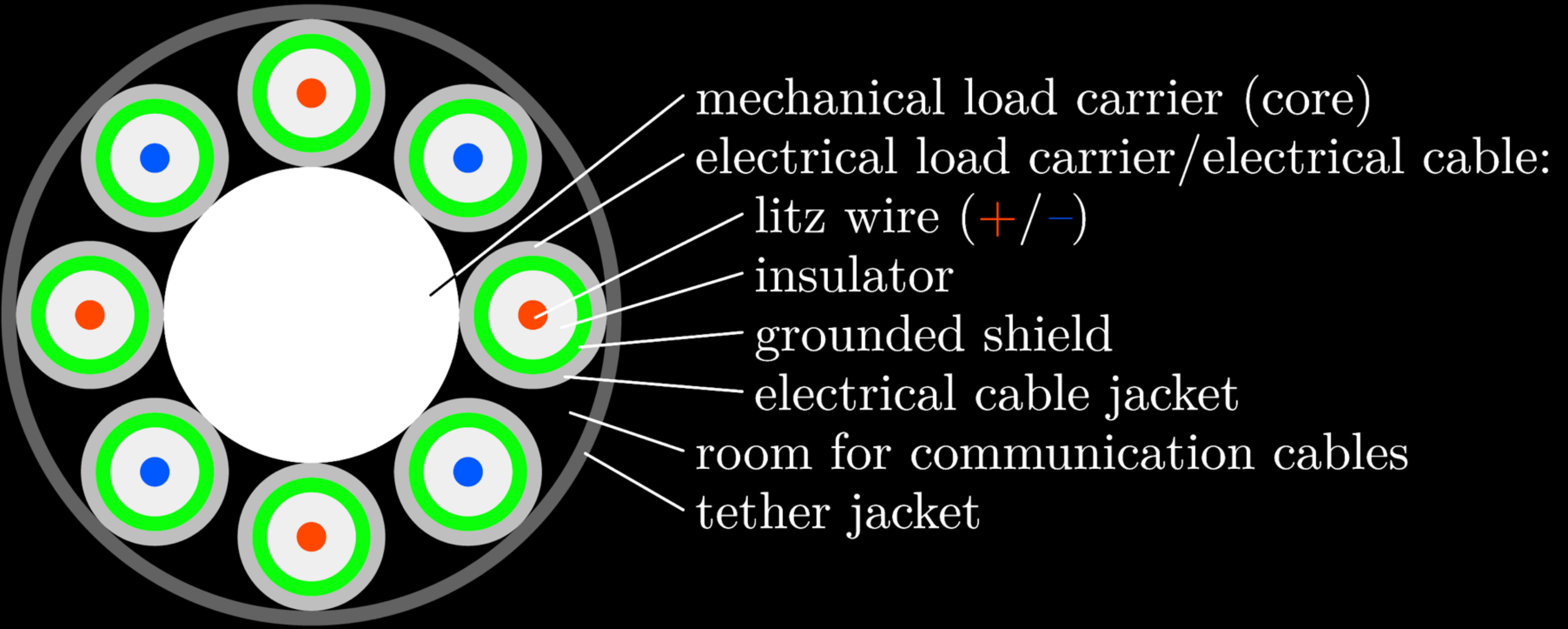


mechanical load carrier (core)
electrical load carrier/electrical cable:
litz wire (+/−)
insulator
grounded shield
electrical cable jacket
room for communication cables
tether jacket



Can be easily modeled mathematically & optimized:

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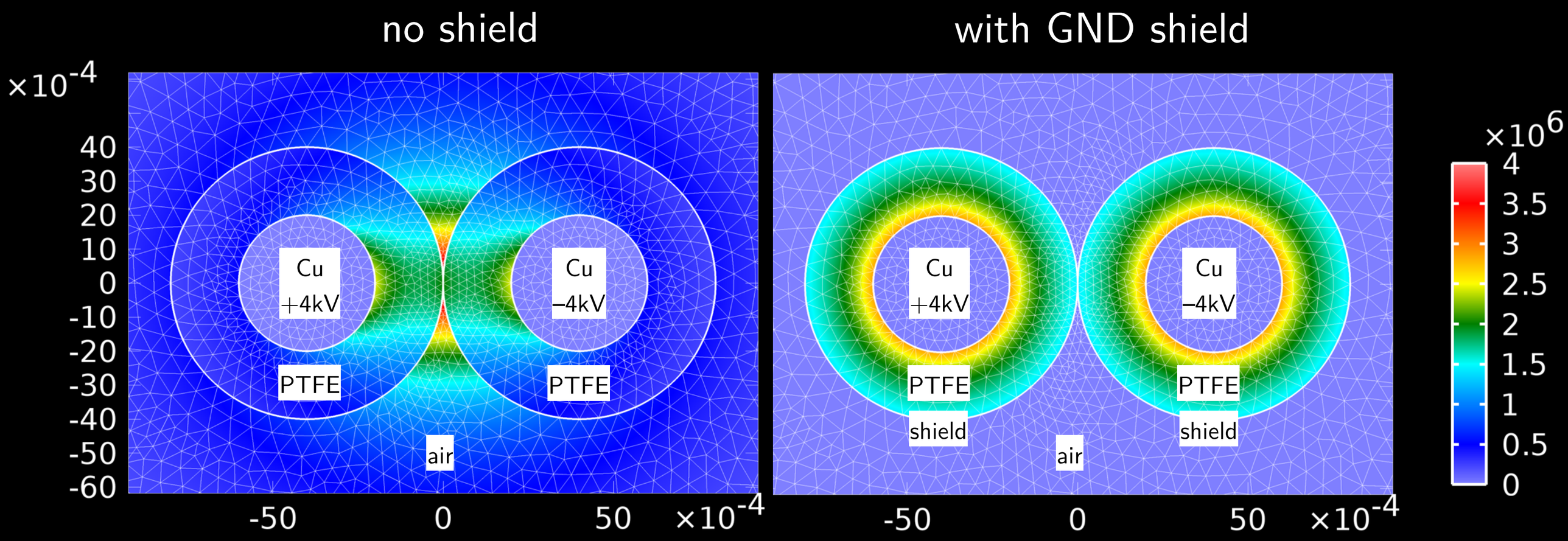
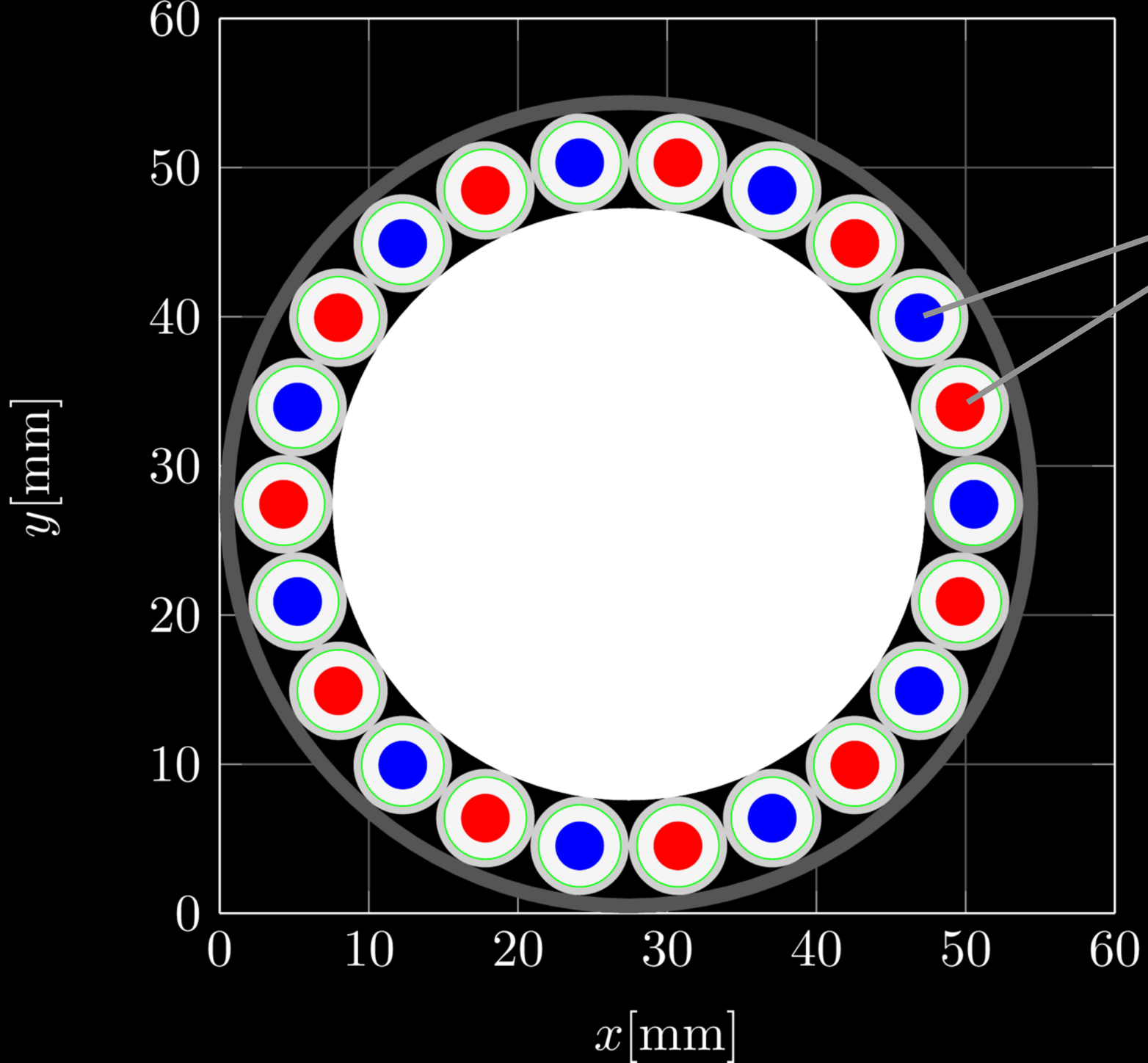


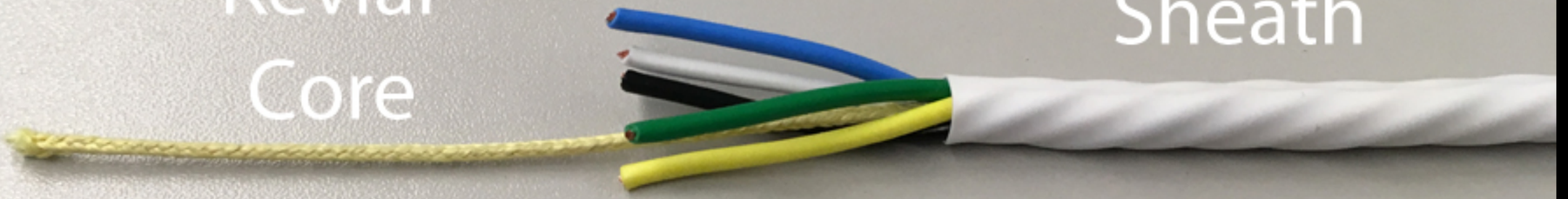
Electric field FEM of two electrical cables in air.



... goes to rotor n (ex.)

Exemplary optimized result for a 4 MW kite.

Electro-Mechanical Tether



Paper Clip for Size Comparison

KITEKRAFT
Clean & Economic Energy

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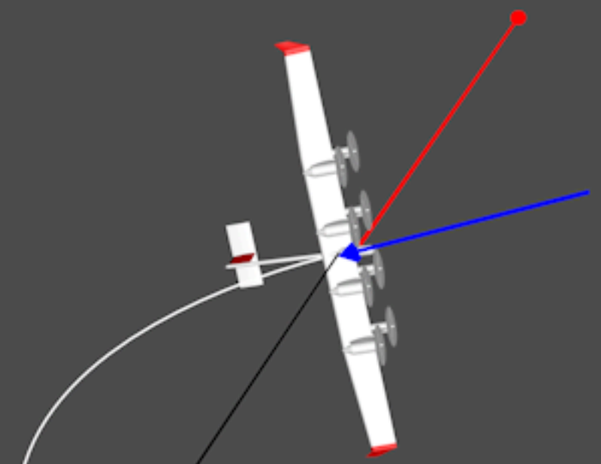
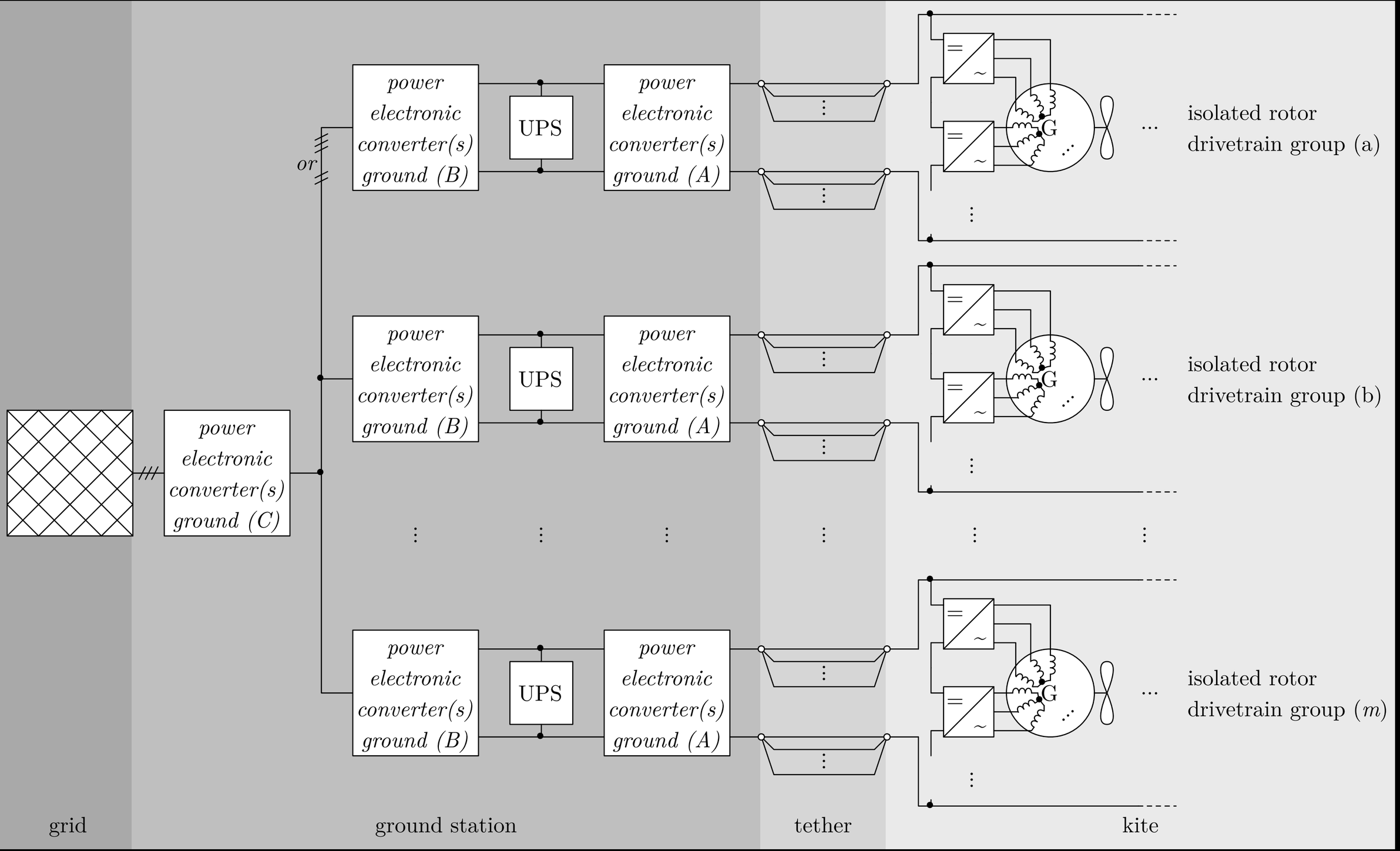


...let's combine the best of the topologies!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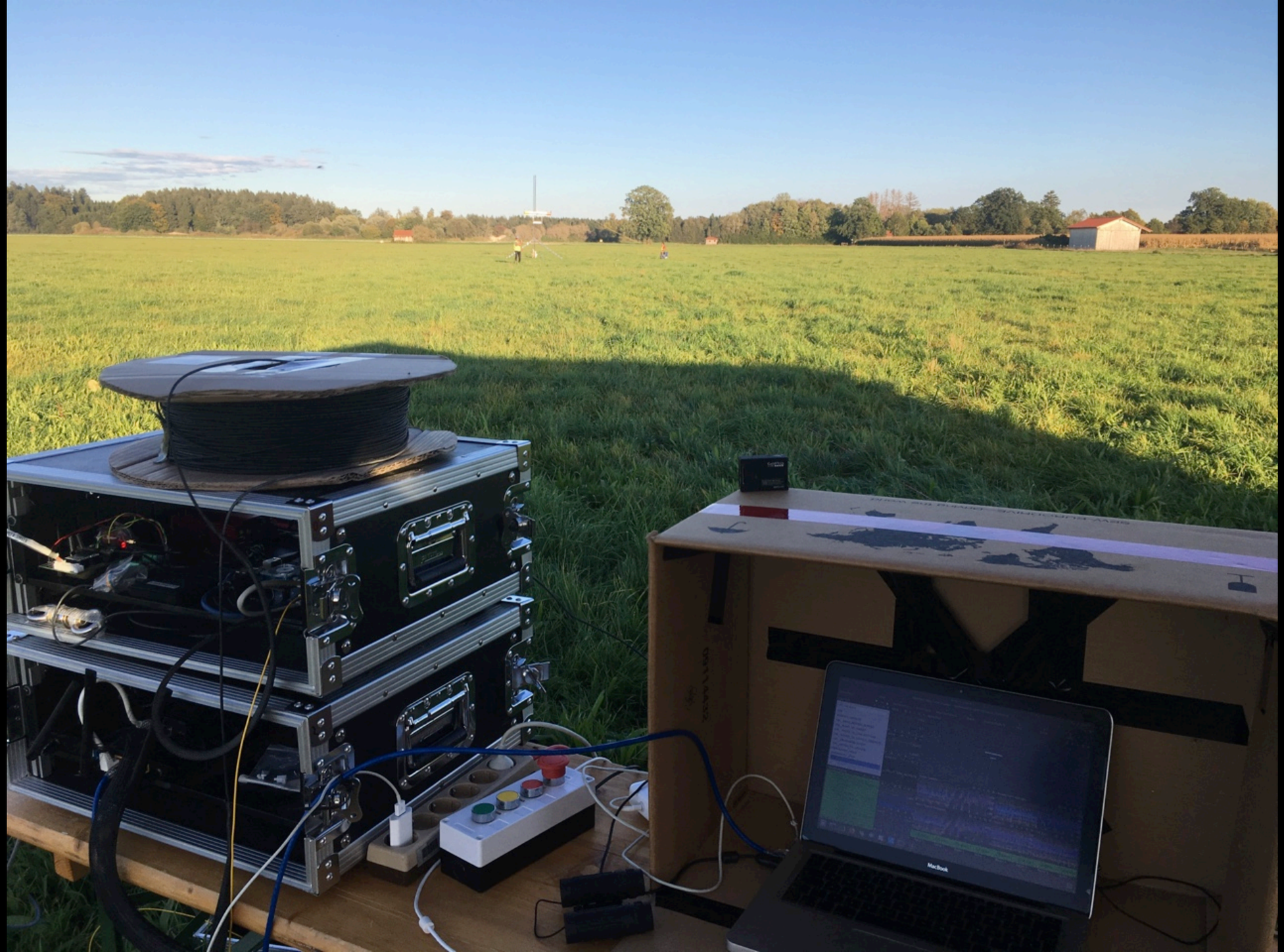
HV+
HV−
V
0
100
200
300
400
500



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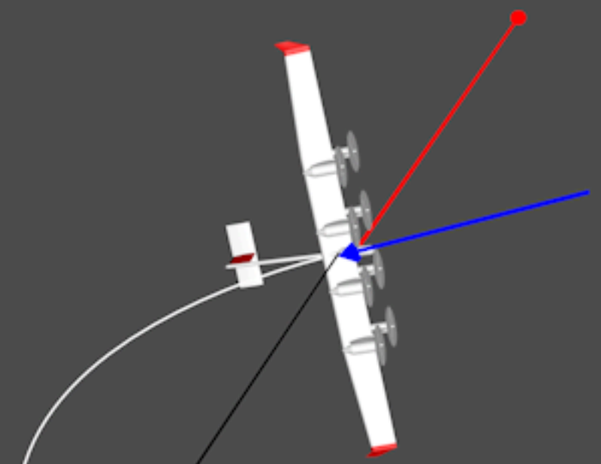

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- topology in part implemented and used at kiteKRAFT, full implementation planned for larger kites

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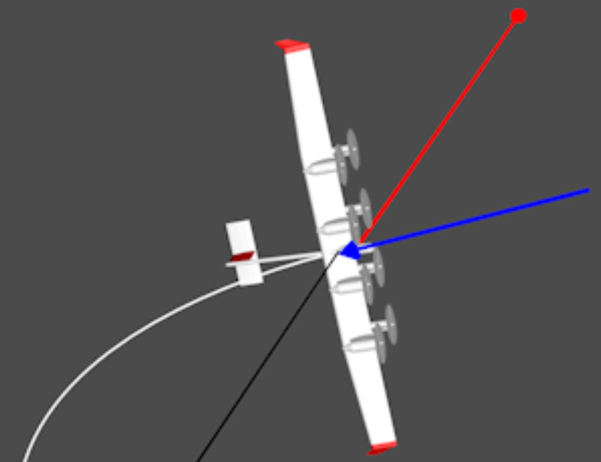

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