EMR'13
Lille
Sept. 2013

Summer School EMR'13
"Energetic Macroscopic Representation"

Open-winding multiphase machines with two different storage sources

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- Outline -

1. **EMR for open-winding multiphase machines**
2. **Inversion-based control of the open-winding machine**
3. **Strategies of control for open-winding machine structure**

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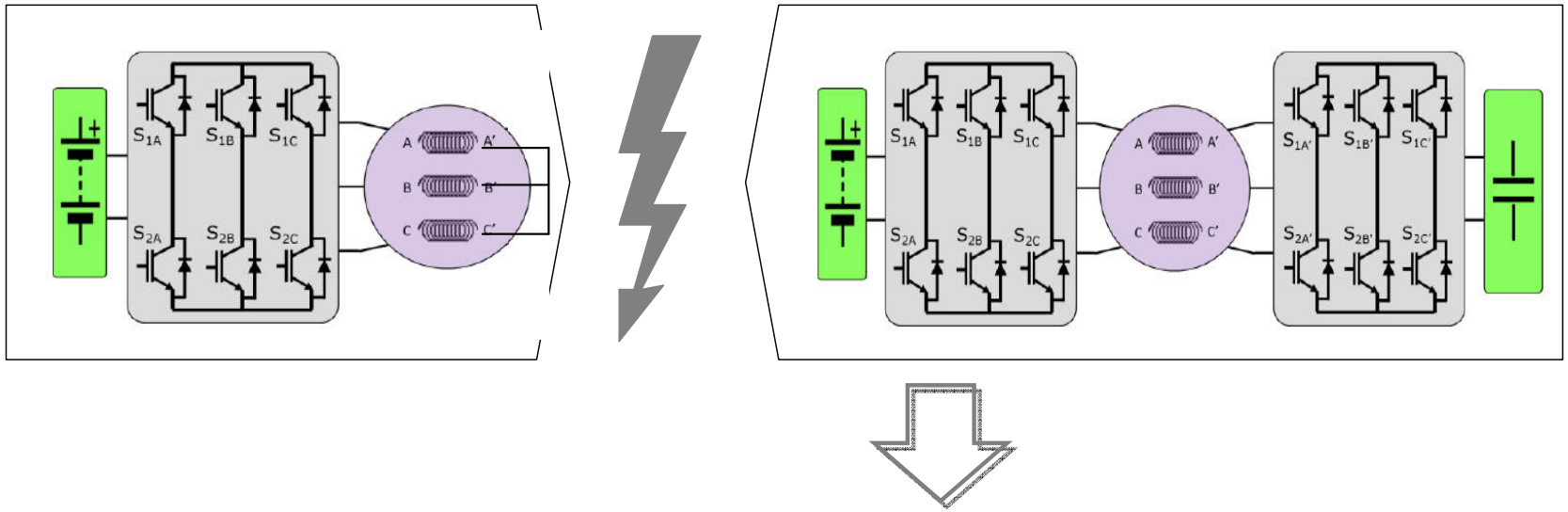
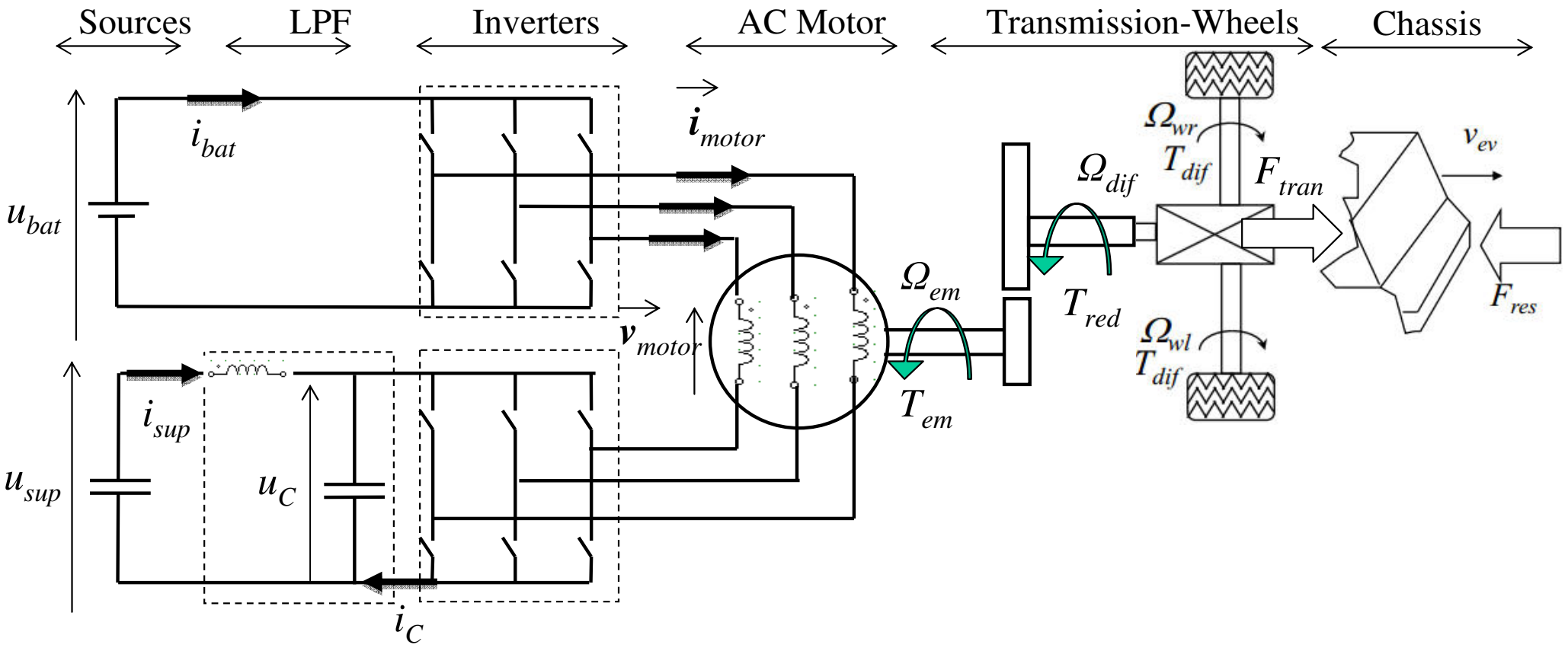
« EMR for open-winding multiphase machines »

One VSI | **Two VSIs**



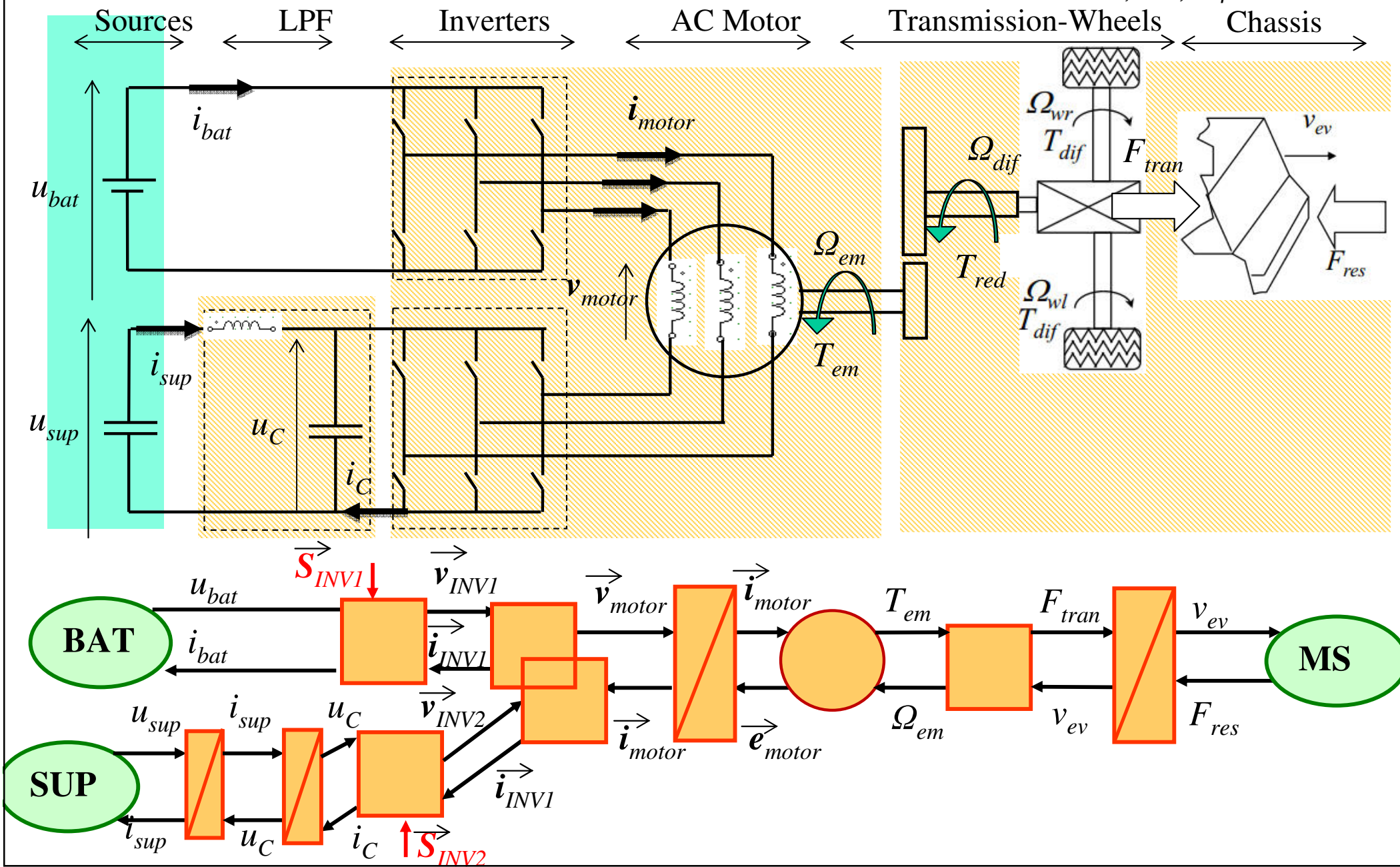
More flexible:

- Different dynamic energy storage sources
- Increasing the battery life
- Increasing the degrees of freedom for control
- Increasing the fault tolerance capacities
- Higher machine voltage


Sources
LPF
Inverters
AC Motor
Transmission-Wheels
Chassis
u_{bat}
i_{bat}
i_{motor}
v_{motor}
Ω_{em}
T_{em}
T_{red}
Ω_{dif}
Ω_{wr}
T_{dif}
F_{tran}
v_{ev}
F_{res}
Ω_{wl}
T_{dif}
u_{sup}
i_{sup}
u_C
i_C

Open-winding multiphase machines with two different storage sources

- EMR for open-winding multiphase machines -



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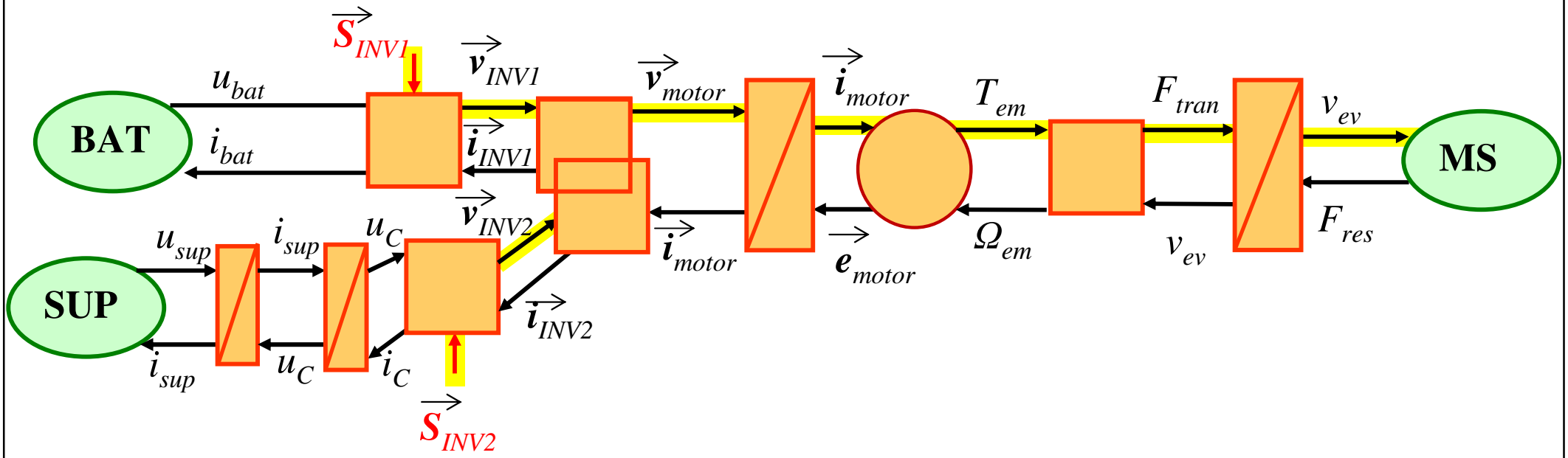
« Inversion-based control of the open-winding machine »

Open-winding multiphase machines with two different storage sources

- Inversion-based control of the open-winding machine -

Sources | LPF | Inverters | AC Motor | Trans.-Wheels | Chassis | Environment



Control objective: v_{ev} ➡ $\vec{v}_{motor}$ *(dimension 3)*

Tuning variables: $\vec{S}_{INV1}$ and $\vec{S}_{INV2}$

(dimension 6)

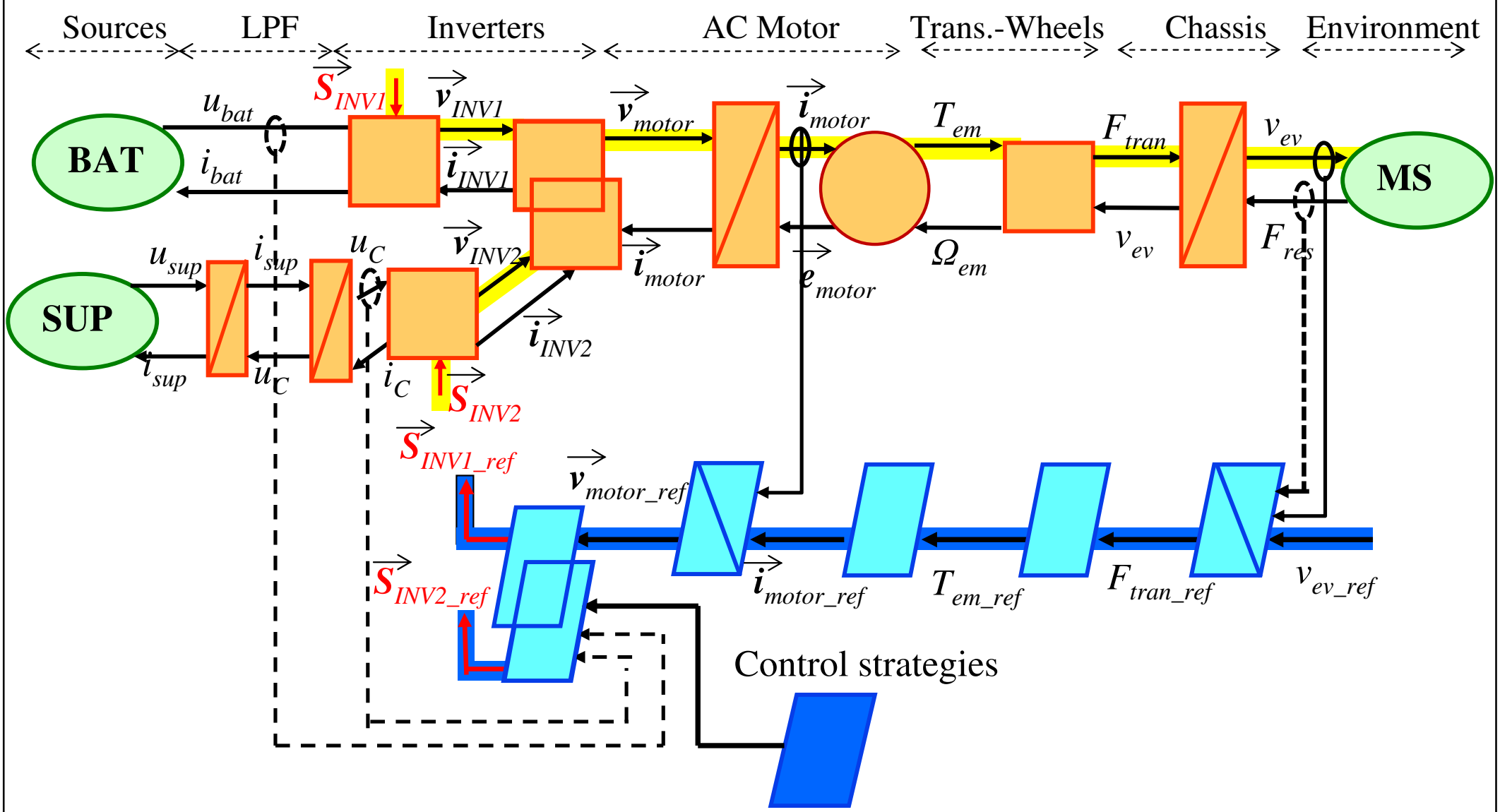
➡ Constraint (6-3=3)

⬇

Strategies of control

Open-winding multiphase machines with two different storage sources

- Inversion-based control of the open-winding machine -



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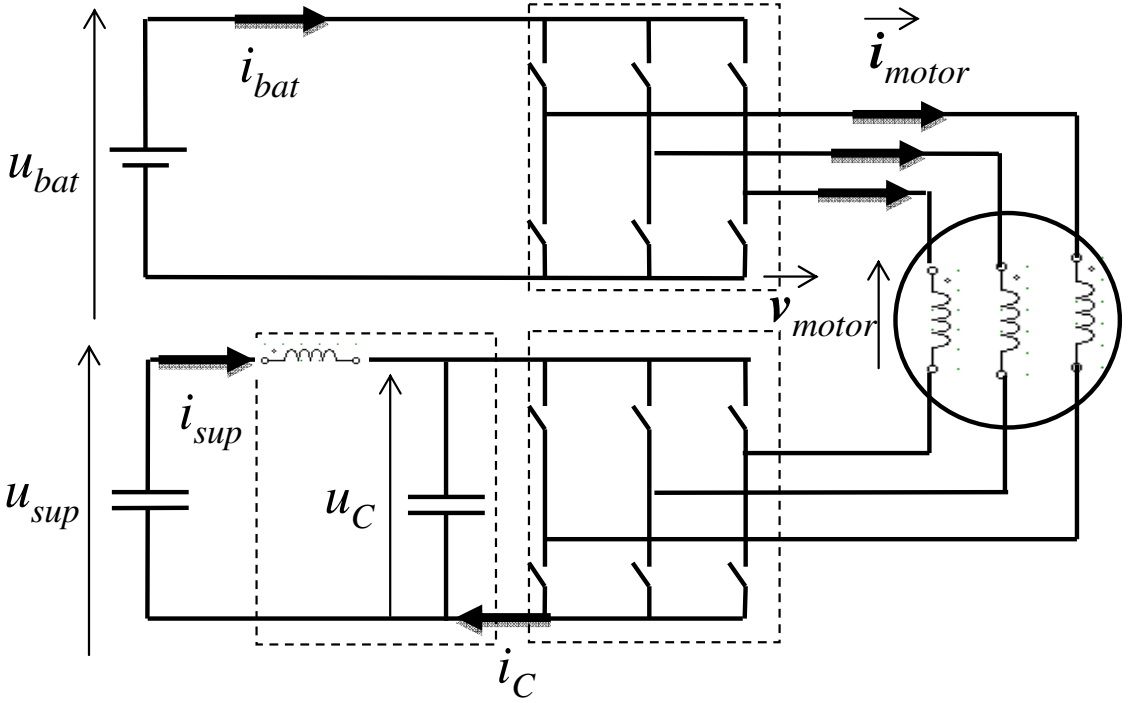
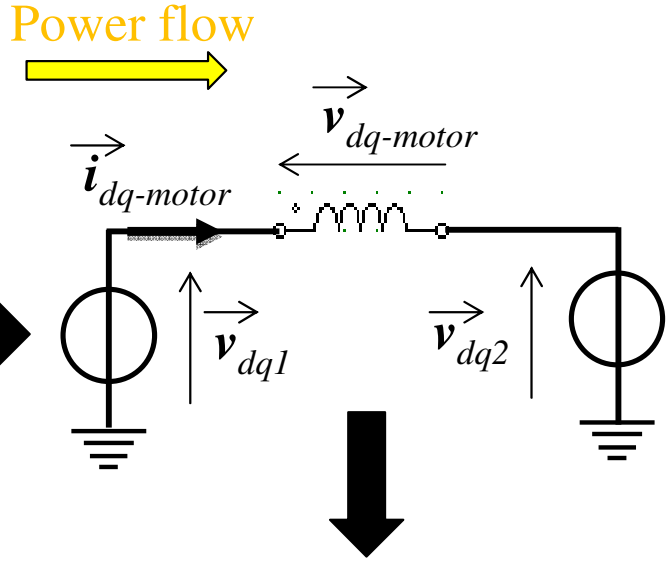
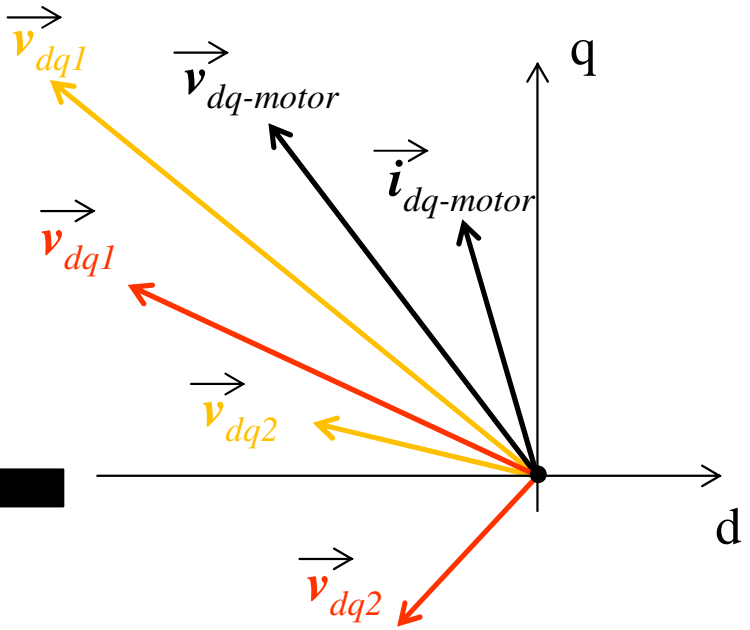
« Strategies of control for open-winding machine structure »



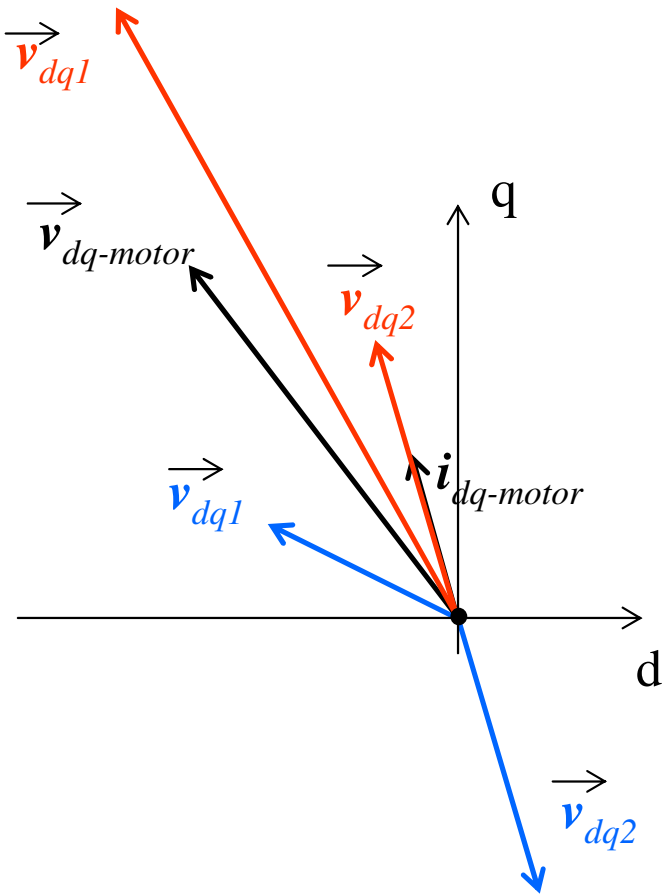


Voltage	$\vec{v}_{dq\text{-}motor} = \vec{v}_{dq1} - \vec{v}_{dq2}$
Power	$P_{motor} = P_1 - P_2$



How can we choose the $\vec{v}_{dq1}$ and $\vec{v}_{dq2}$ vectors?

Unity Power Factor Control [Welchko 05]



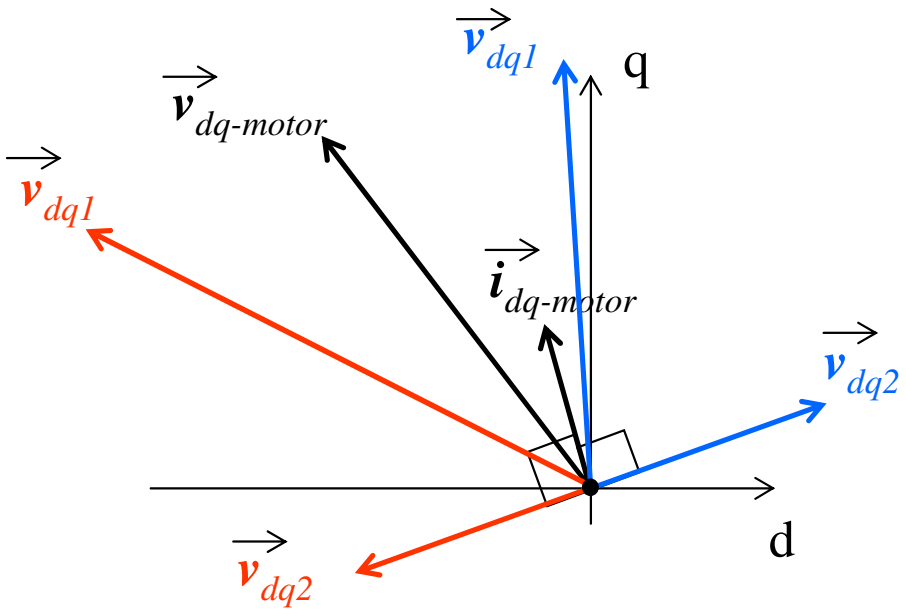
Voltage	$\vec{v}_{dq\text{-}motor} = \vec{v}_{dq1} - \vec{v}_{dq2}$
Power	$P_{motor} = P_1 - P_2$

The power (acceleration or break) of the super-capacitor is maximized

Acceleration

Regenerative breaking

Quadrature voltage control [Welchko 05]



Voltage	$\vec{v}_{dq\text{-}motor} = \vec{v}_{dq1} - \vec{v}_{dq2}$
Power	$P_{motor} = P_1 - P_2$

The active power of the super-capacitor is null

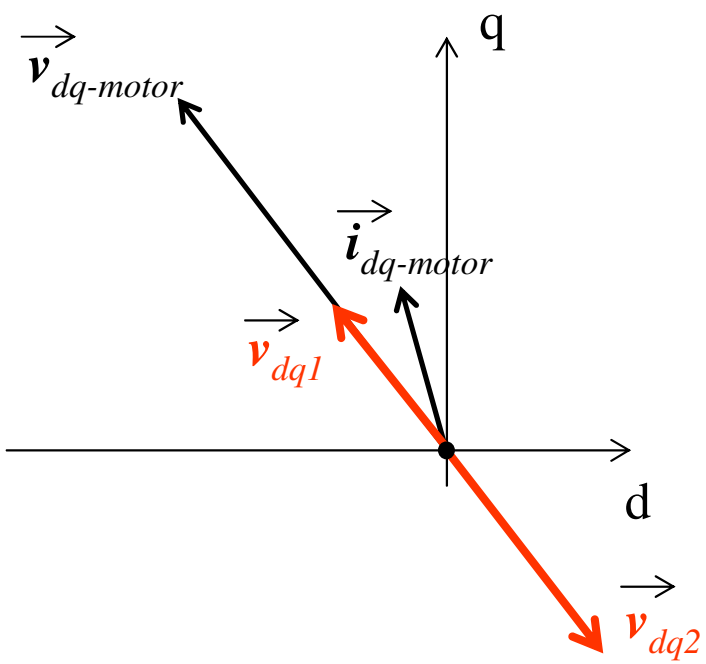
⇓

Speed constant

Blue: INV2 is considered as a "capacitor" ⇒ High power factor of INV1

Red: INV2 is considered as a "winding" ⇒ Low power factor of INV1

Maximum voltage control [Welchko 05]

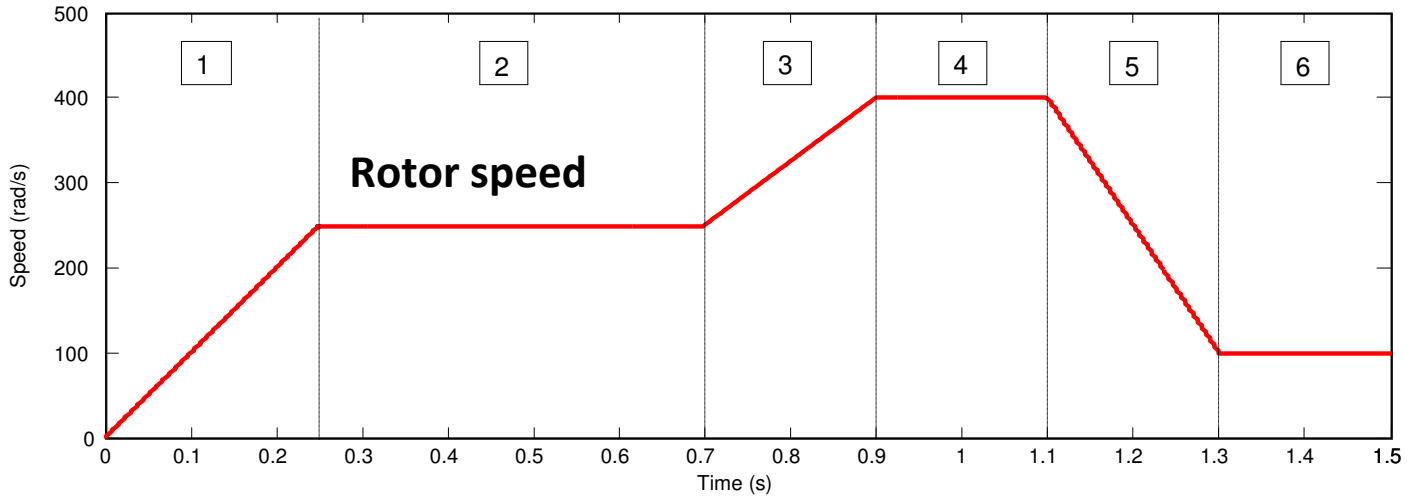


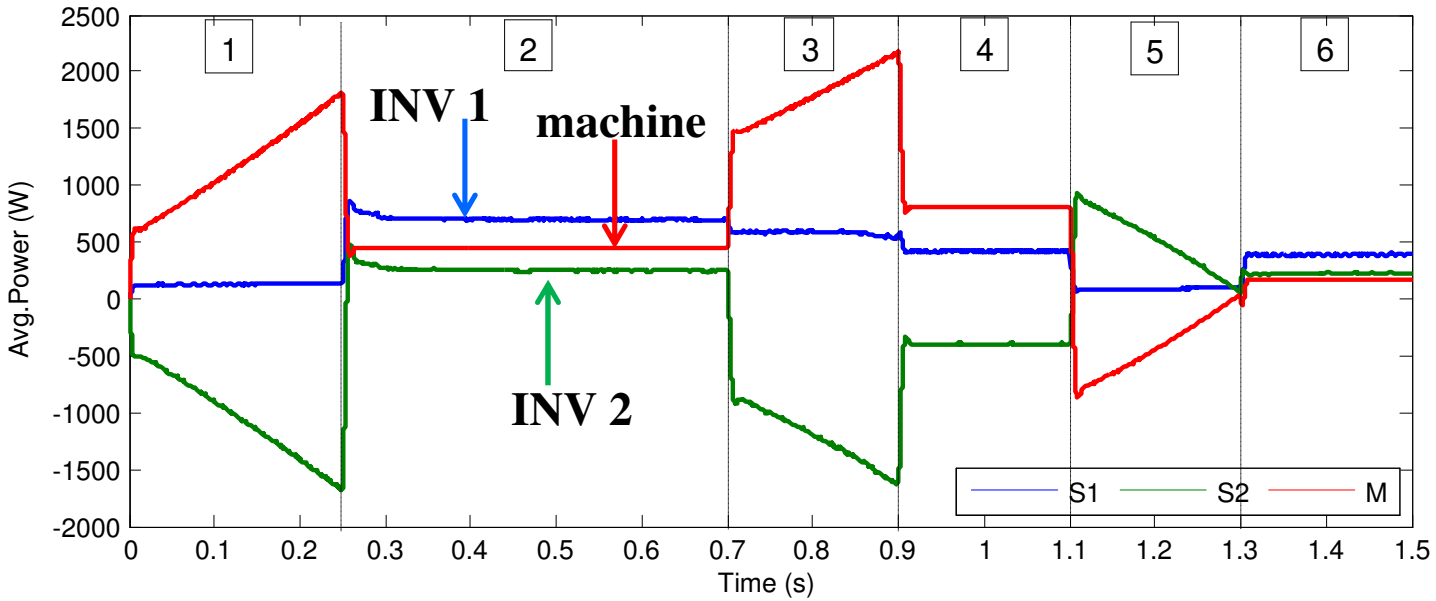
Voltage	$\vec{v}_{dq\text{-}motor} = \vec{v}_{dq1} - \vec{v}_{dq2}$
Power	$P_{motor} = P_1 - P_2$

Maximum machine voltage

High speed

Simulation result

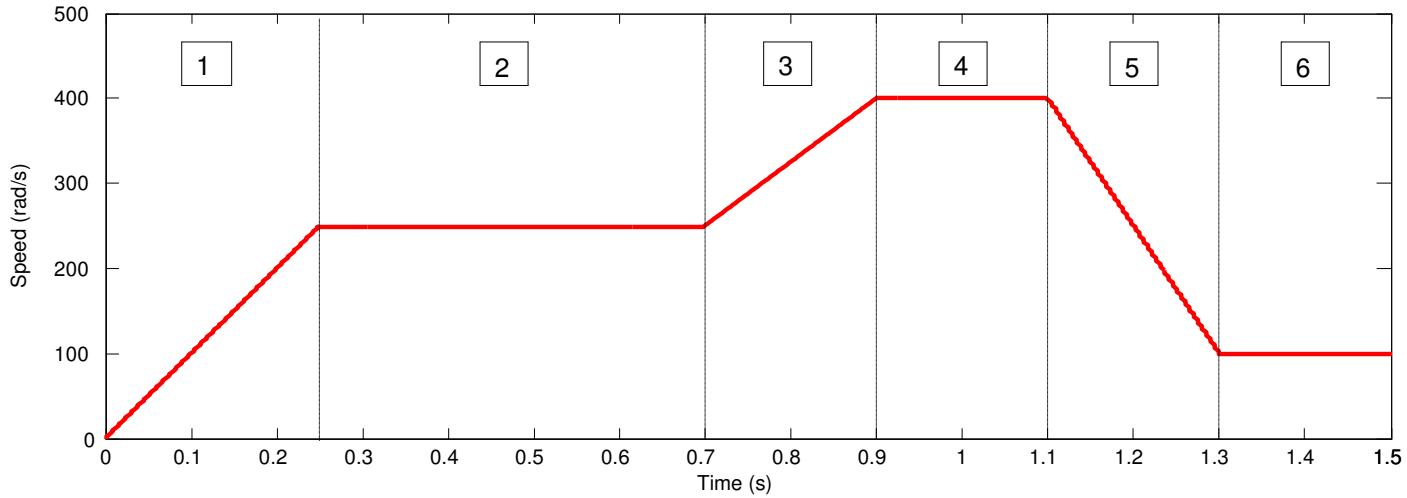




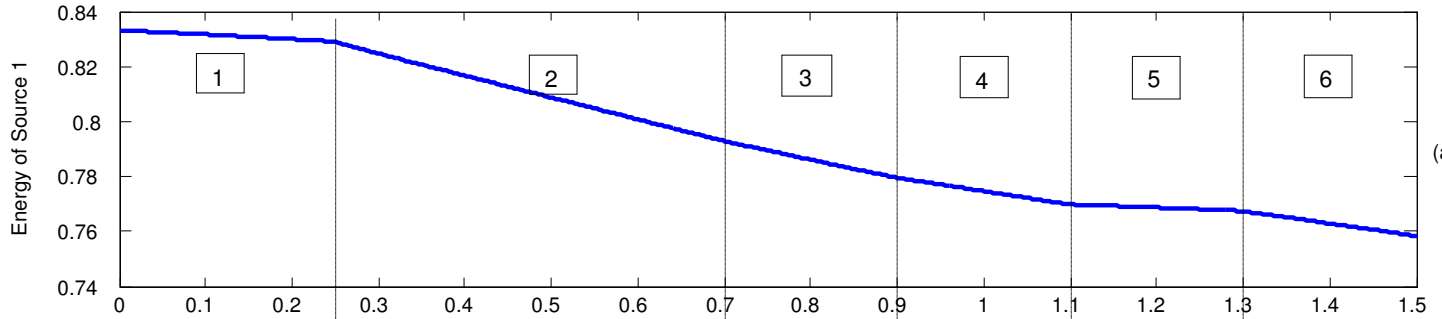
1. Super-capacitor is used mainly.
2. Battery supplies and super-capacitor is charged.
3. Super-capacitor is used mainly.
4. Super-capacitor and battery are used.
5. Super-capacitor is charged (regenerative brake).
6. Battery supplies and super-capacitor is charged.

Simulation result

Rotor speed

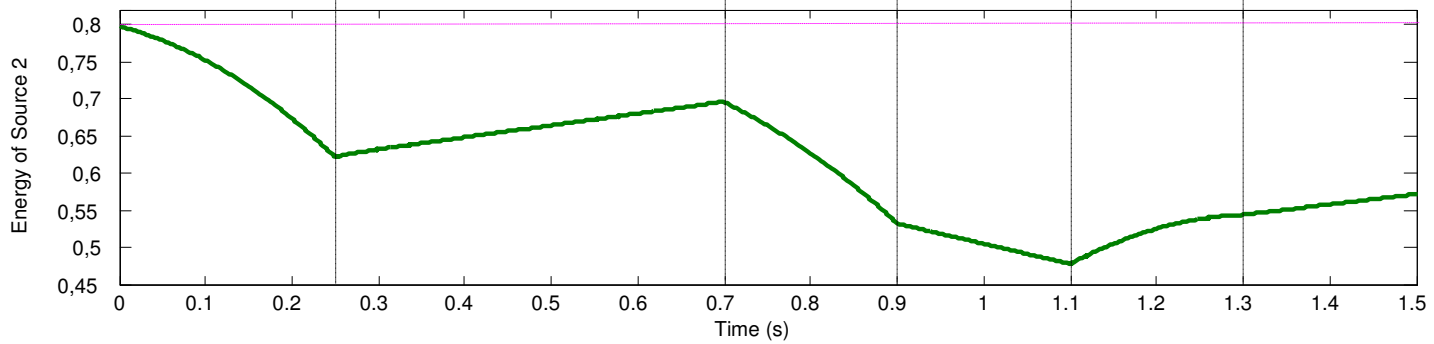


Battery energy



(a)

Super-capacitor energy



(b)

« BIOGRAPHIES AND REFERENCES »

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PhD in Electrical Engineering at University Lille1 (2000)
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Research topics: Multiphase machines design and control, multi-converter modelling

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