Simulation is a key issue before working on a real system...

Which kind of model?

How to organize simulation? Control?

How to represent the model?

Tazzari Zero of L2EP
1. Studied EV

2. EMR of the studied EV

3. Inversion-based control of the EV
**Tazzari Zero characteristics**

- 15 kW induction machine
- 80V 160Ah LiFePO4 battery
- 542 kg (empty mass)
- Maximum speed: 85km/h
Objective:
control of the traction system in straight lines

Simplifications:
• a permanent magnet DC machine is considered in a first step
• an equivalent wheel is considered (no curve)
« EMR OF THE STUDIED ELECTRIC VEHICLE »
EMR and IBC of an Electric Vehicle

- EMR of the EV -

Battery

Structural Representation

\[ u_{bat} \]

\[ i_{chop} \]

\[ m_{chop} \]

\[ u_{chop} = m_{chop} V_{bat} \]

\[ i_{chop} = m_{chop} i_{arm} \]

Functional Description
\[ L_{\text{arm}} \frac{d}{dt} i_{\text{dc}} = u_{\text{chop}} - e_{\text{dc}} - R_{\text{arm}} i_{\text{dc}} \]

\[ T_{\text{dc}} = k_{\text{dc}} i_{\text{dc}} \]

\[ e_{\text{dc}} = k_{\text{dc}} \Omega_{\text{shaft}} \]

\[ J \frac{d}{dt} \Omega_{\text{shaft}} = T_{\text{dc}} - T_{\text{gear}} - f\Omega_{\text{shaft}} \]
EMR and IBC of an Electric Vehicle

- EMR of the EV -

\[
\begin{align*}
T_{dcm} &= k_{gear} T_{diff} \\
\Omega_{gear} &= k_{gear} \Omega_{shaft} \\
T_{diff} &= k_{dif} T_{wh} \\
\Omega_{diff} &= k_{dif} \Omega_{gear} \\
v_{ev} &= R_{wh} \Omega_{diff} \\
\end{align*}
\]
EMR and IBC of an Electric Vehicle

- EMR of the EV -

$$M \frac{dv_{ev}}{dt} = F_{wh} - F_{res}$$

- Diagram showing battery, chop, gear, and wheel connections.
**Conflict of association:**

\( \Omega_{shaft} \) and \( v_{ev} \) state variables, but

\[ v_{ev} = R_{wh} k_{diff} k_{gear} \Omega_{shaft} \]
Conflict of association:
a unique state variable is required!

\[ M_{eq} \frac{dv_{ev}}{dt} = F_{wh} - F_{res} \]

\[ M_{eq} = M + \frac{J_{shaft}}{k_{gear}^8 k_{diff}^4 R_{wh}^2} \]
\[ F_{\text{res}} = k_{\text{roll}} Mg \cos \alpha + \frac{1}{2} \rho_{\text{air}} AC_x v_{\text{ev}}^2 + Mg \sin \alpha \]
« Inversion-based Control of the Studied Electric Vehicle »
Objective: control the EV velocity

Tuning variable: modulation ratio of the DC-DC converter
Maximum Control Structure:
- inversion of each element step-by-step
- all variables are assumed measurable
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• inversion of each element step-by-step
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Example of simplification:
• merging of gains $k_{tot}=k_1k_2k_3k_4$
Example of estimation:
- estimation of velocity
Matlab-Simulink ©, using the EMR library
Electronic Control Unit

sensors
« REFERENCES »


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