Quantifizierung der Degeneration von Wechselrichtern mittels datenbasierter Schätzmethoden

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University of Applied Sciences

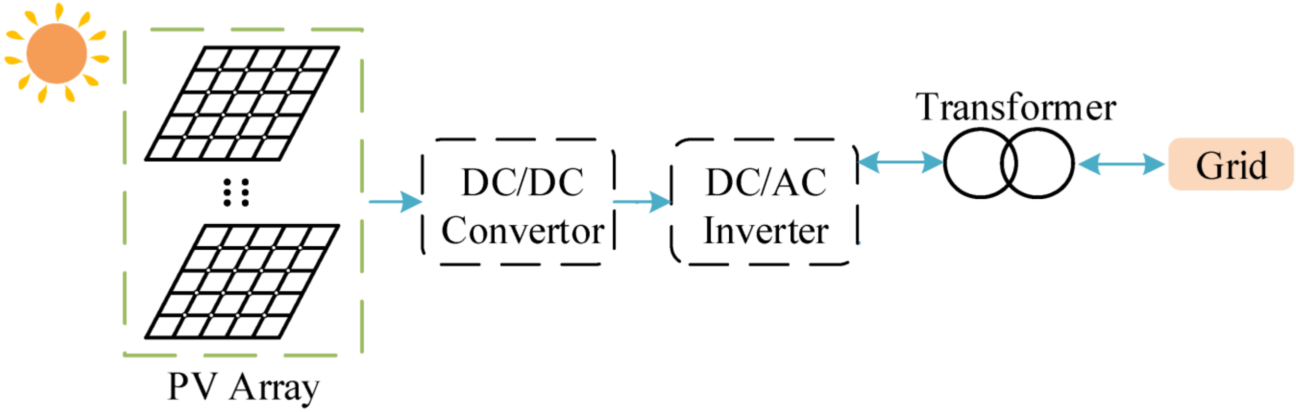
1. PV Inverter

▪Quelle: https://kaco-newenergy.com/fileadmin/_processed_/0/b/csm_KNE-IMG-Slider-Utility-CPSS-bp-125TL3_e806e157e9.jpg

1. PV Inverter

Quelle: https://ae-pic-a1.aliexpress-media.com/kf/Sb84e55acd8664ee2a582cbf5fd0e270aV.jpg_960x960q75.jpg_.avif

1. PV Inverter



Quelle: https://doi.org/10.3390/en17071571

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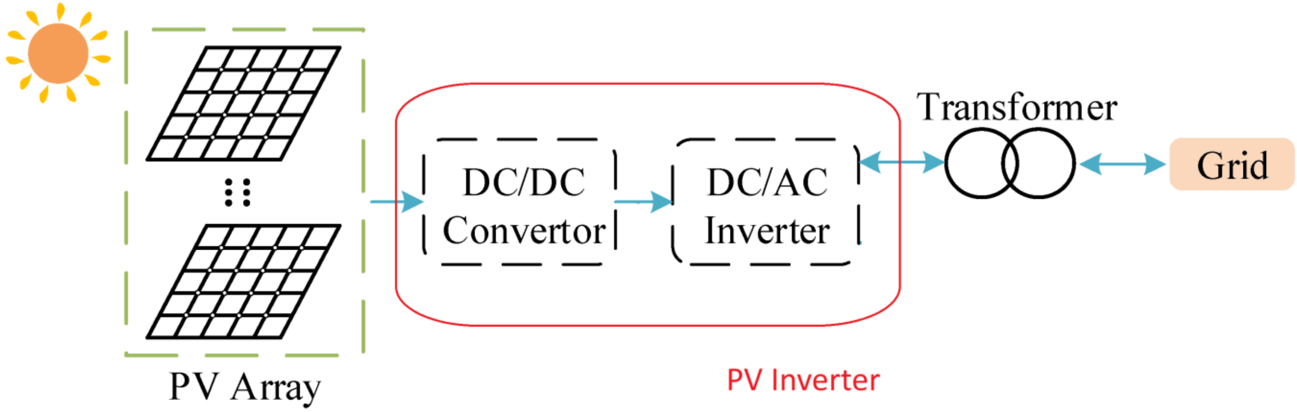

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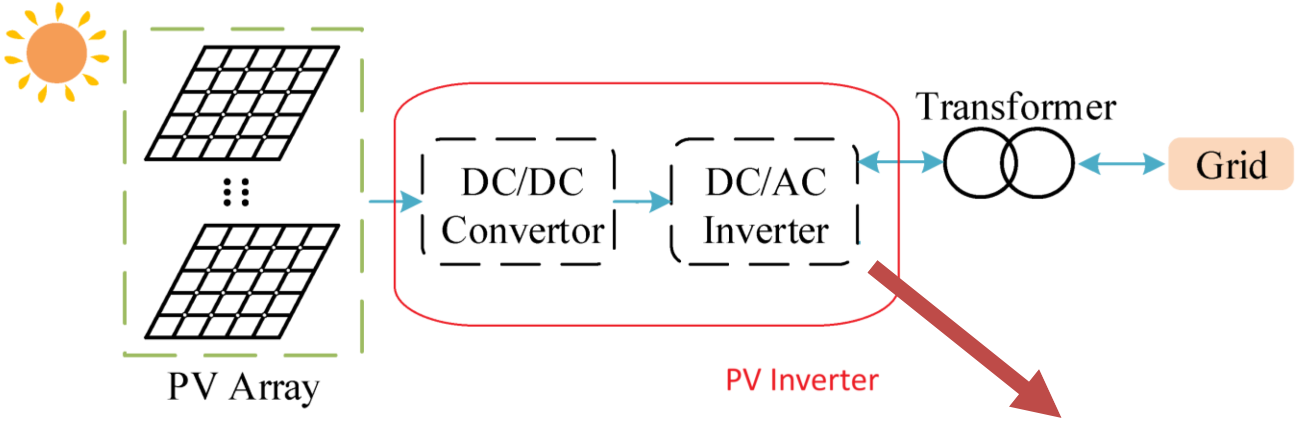

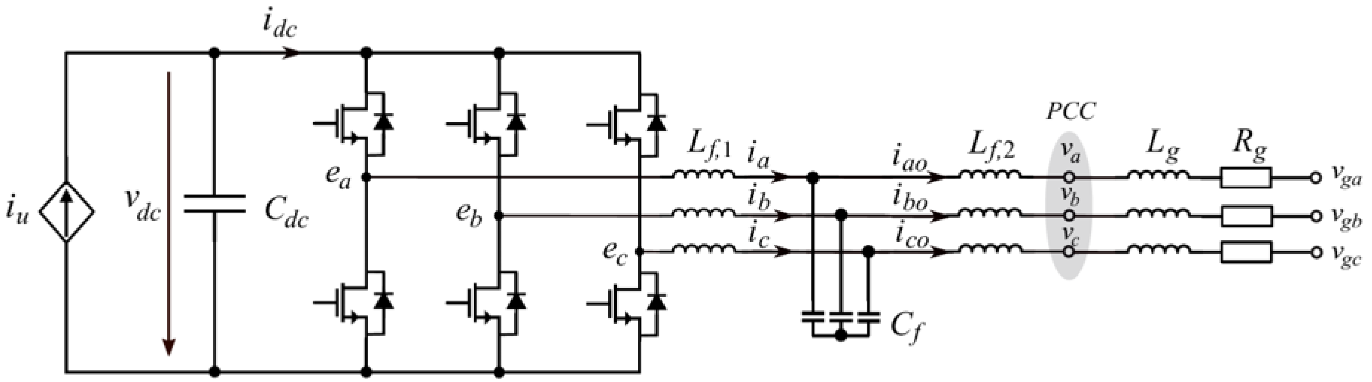

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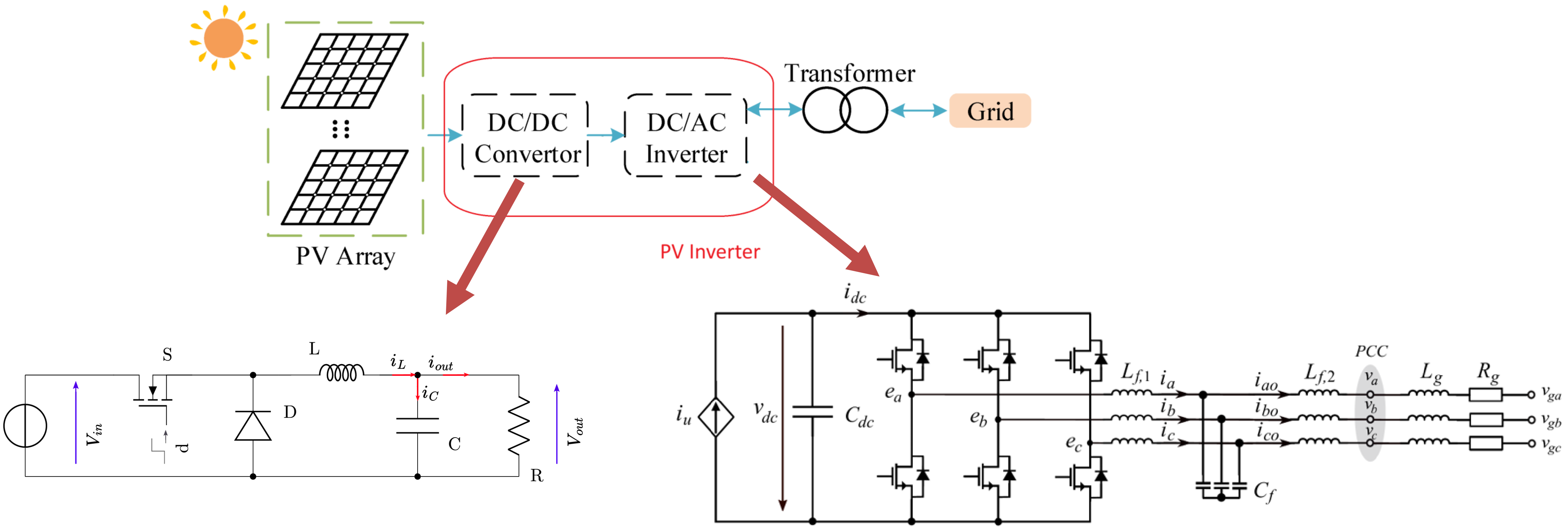

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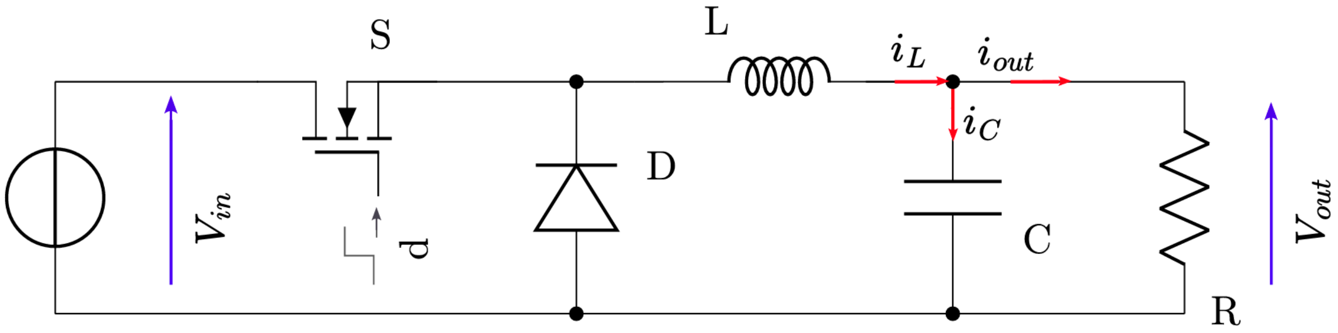
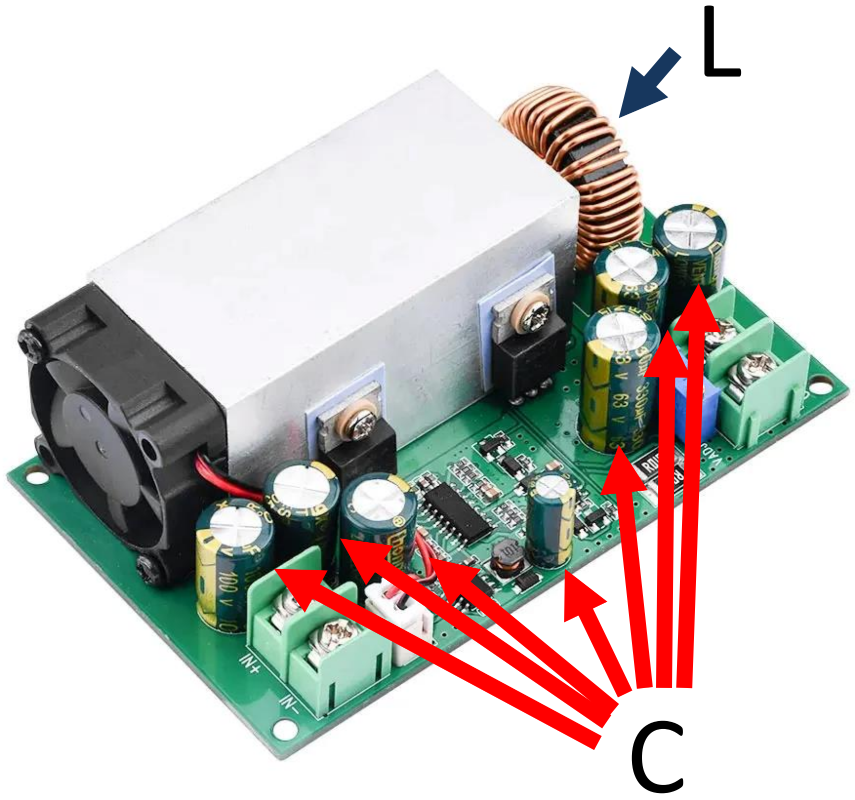
2. Buck Converter Model





$$\dot{x}_1 = -\frac{1}{L}x_2 + \frac{d}{L}u_1$$

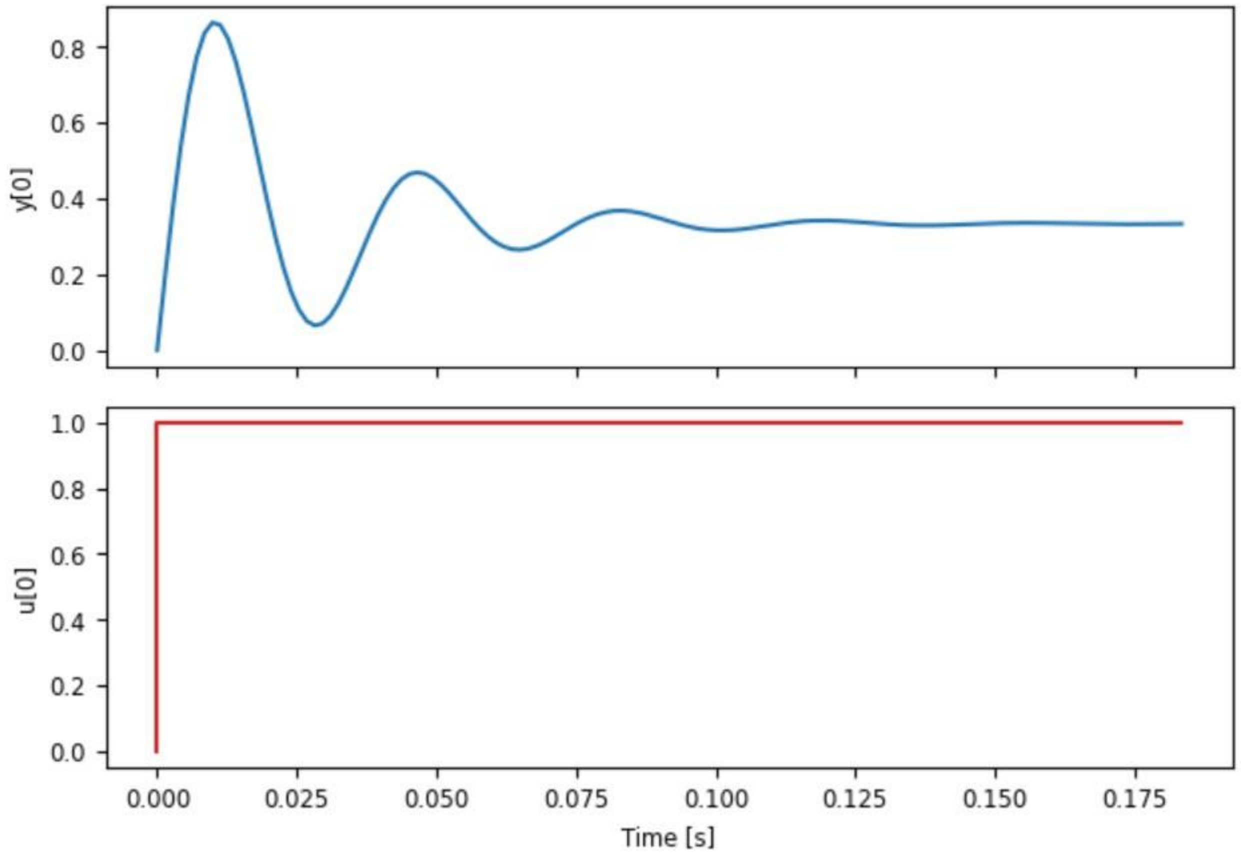
$$\dot{x}_2 = \frac{1}{C}x_1 - \frac{1}{RC}x_2$$

with $x_1 = i_L$, $x_2 = V_{out}$, $u_1 = V_{in}$

Quelle: https://www.esig.energy/wiki-main-page/user-guide-for-pv-dynamic-model-simulation-written-on-pscad-platform/

2. Buck Converter Model

DC/AC Grid Side Converter



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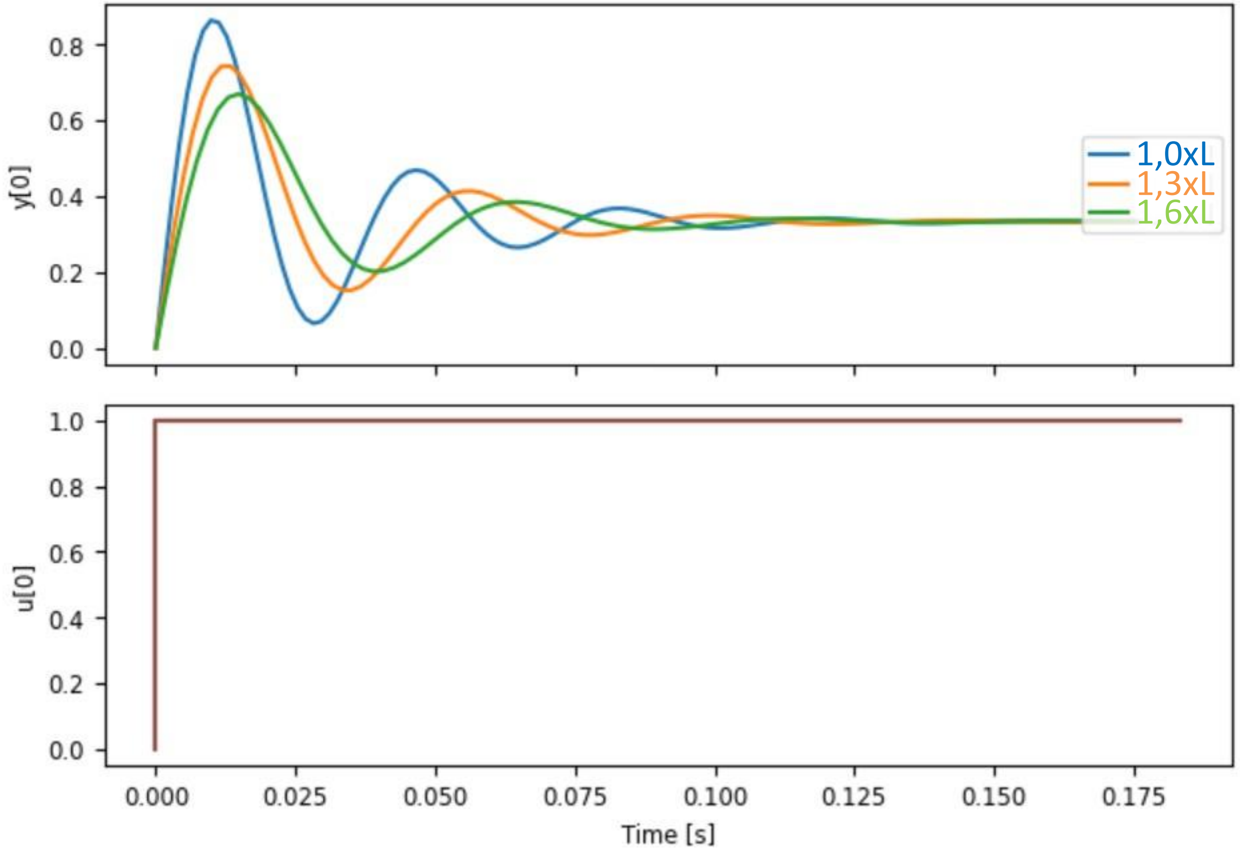

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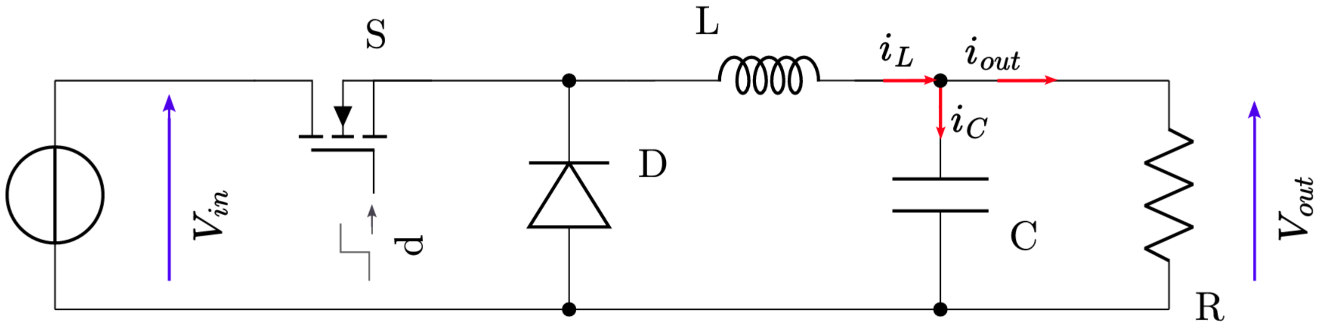
2. Buck Converter Model

- State-Space Average Model



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with $x_1 = i_L,\ x_2 = V_{out},\ u_1 = V_{in}$

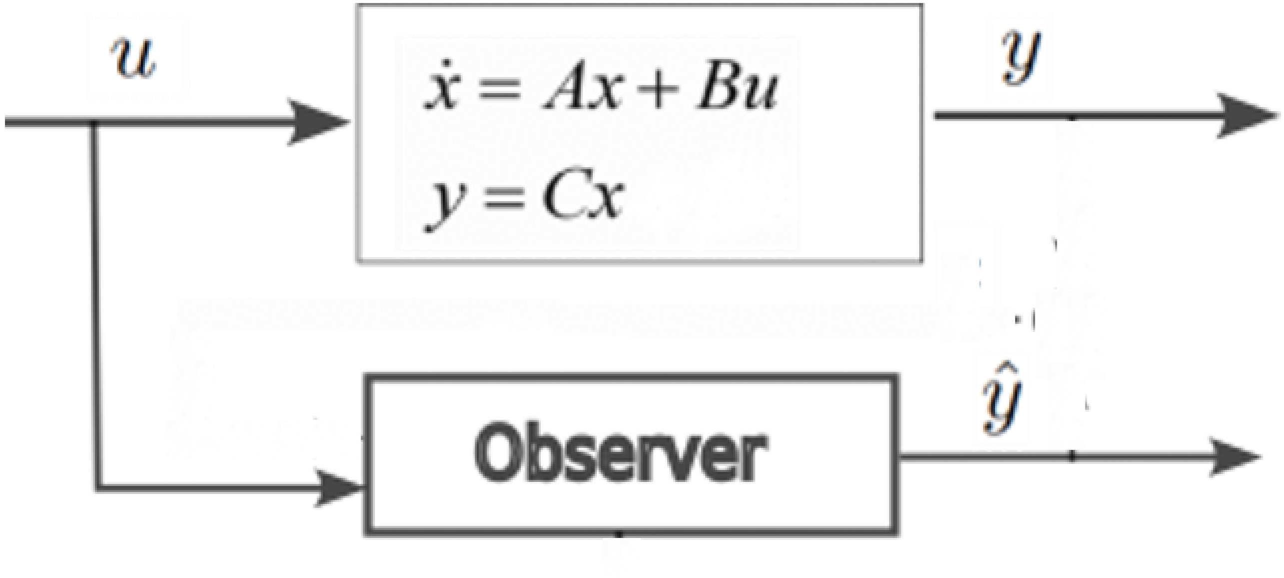
$$\dot{x} = \begin{bmatrix} 0 & -\frac{1}{L} \\ \frac{1}{C} & -\frac{1}{RC} \end{bmatrix} x + \begin{bmatrix} \frac{d}{L} \\ 0 \end{bmatrix} u$$

$$x = \begin{bmatrix} i_L \\ V_o \end{bmatrix}$$

$$d \in [0, 1]$$

3. Observer

DC/AC Grid Side Converter



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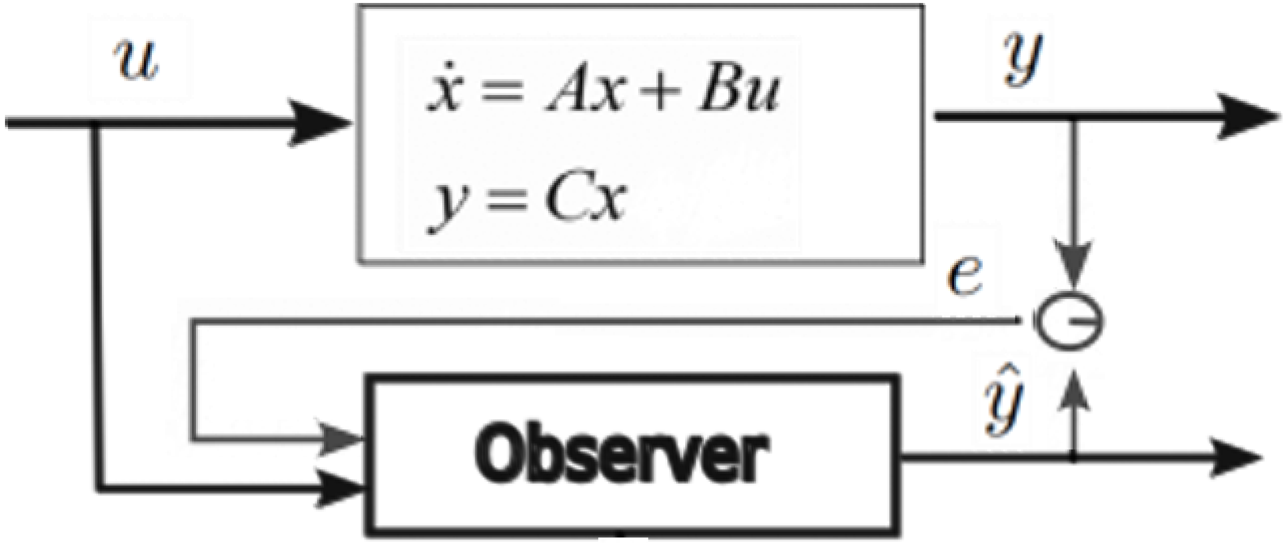

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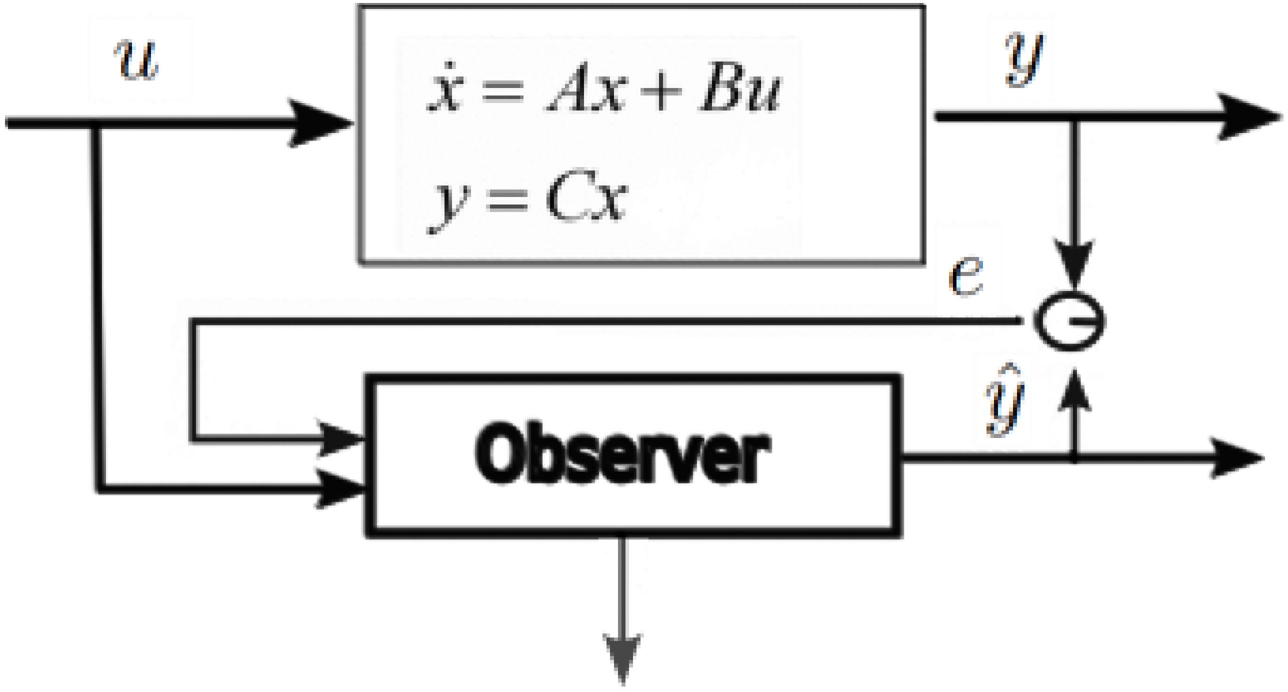
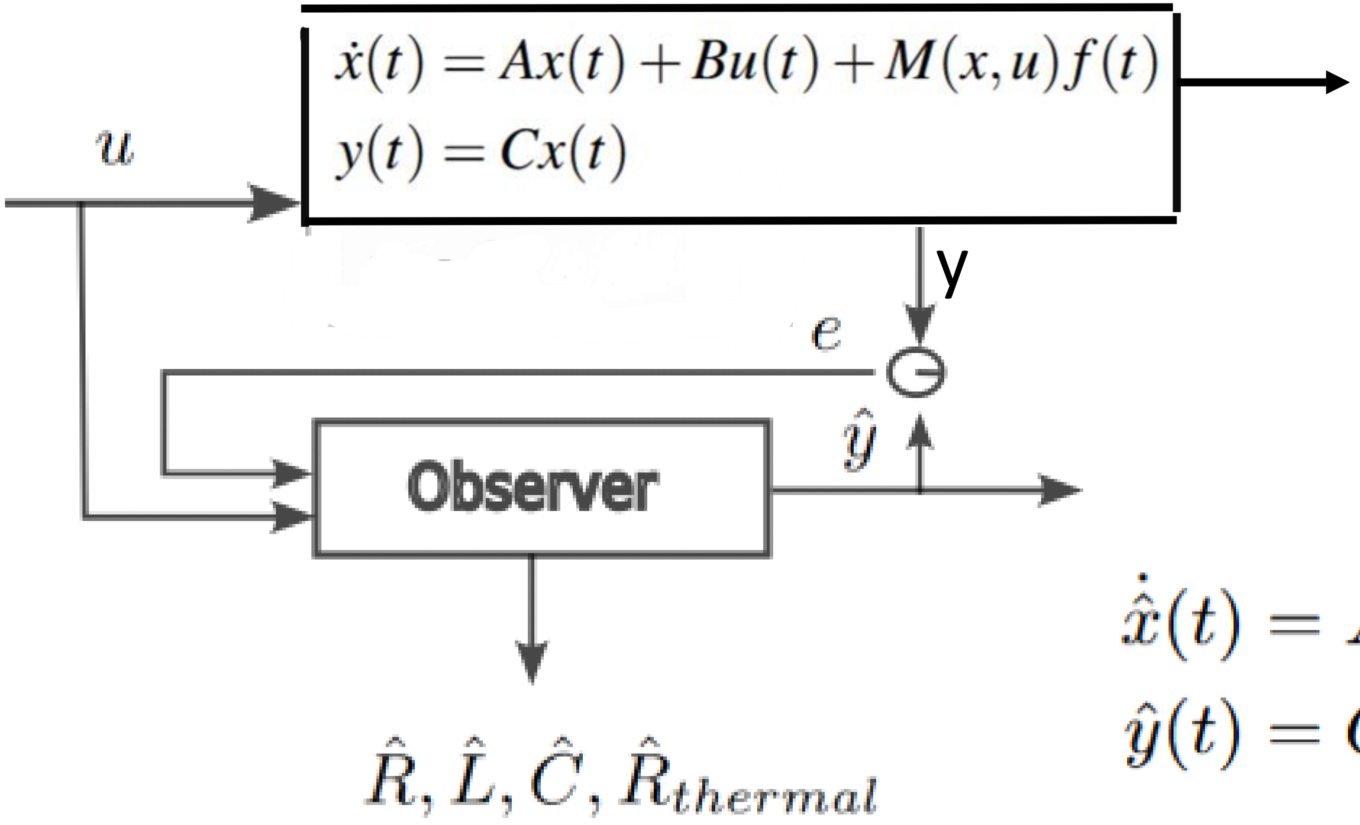


$$\hat{R}, \hat{L}, \hat{C}, \hat{R}_{thermal}$$

3. Observer



$$\dot{\hat{x}}(t) = A\hat{x}(t) + Bu(t) - G_l e_y(t) + G_n \nu$$

$$\hat{y}(t) = C\hat{x}(t)$$

$$\nu = -\rho \frac{P_2 e_y}{||P_2 e_y||} \quad \textbf{if } e_y \neq 0$$

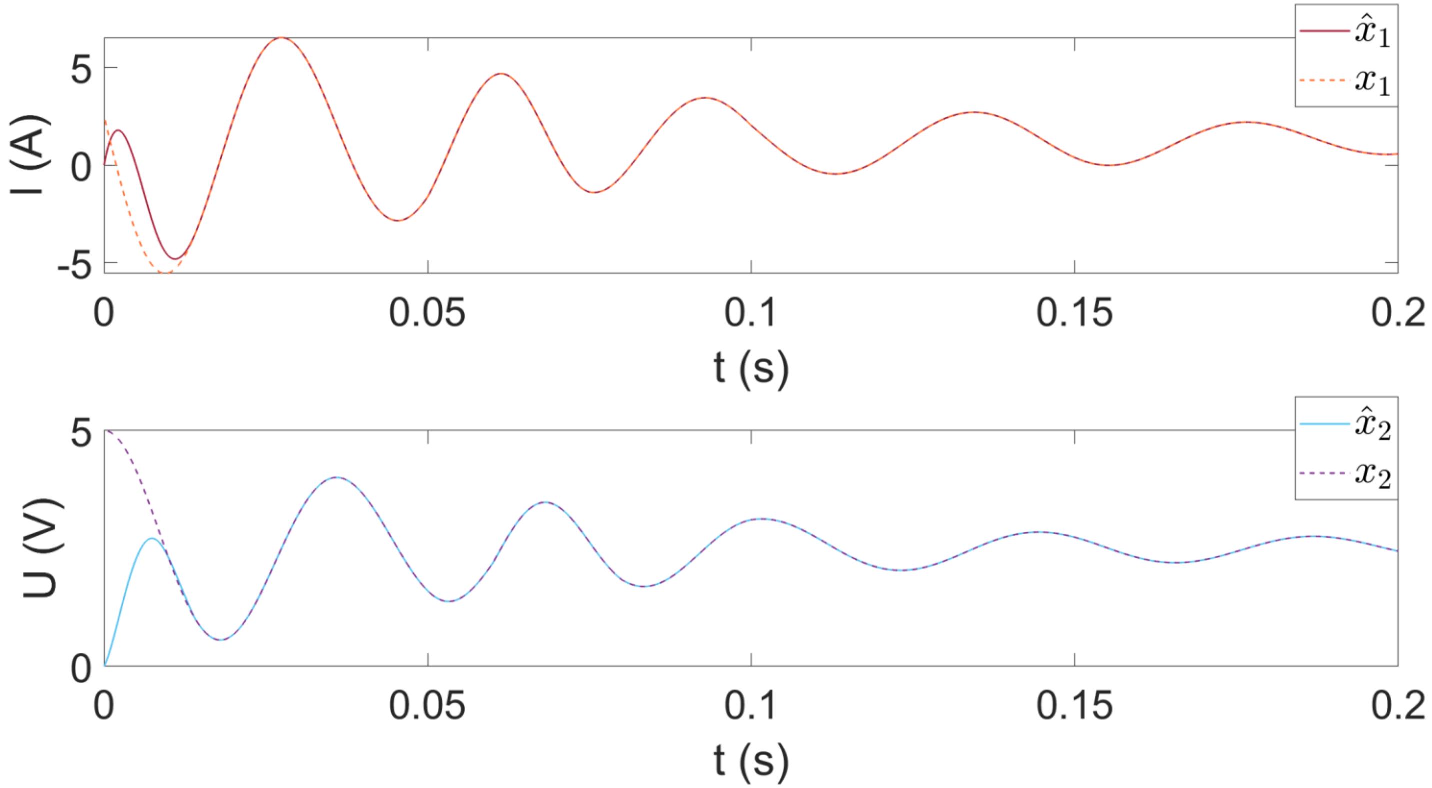
Das Bildelement mit der Beziehungs-ID rId2 wurde in der Datei nicht gefunden.

4. Simulation Results

Buck converter Model

- State-Space Average Model

$$\dot{x} = \begin{bmatrix} 0 & -\frac{1}{L} \\ \frac{1}{C} & -\frac{1}{RC} \end{bmatrix} x + \begin{bmatrix} \frac{d}{L} \\ 0 \end{bmatrix} u \qquad x = \begin{bmatrix} i_L \\ V_o \end{bmatrix}$$



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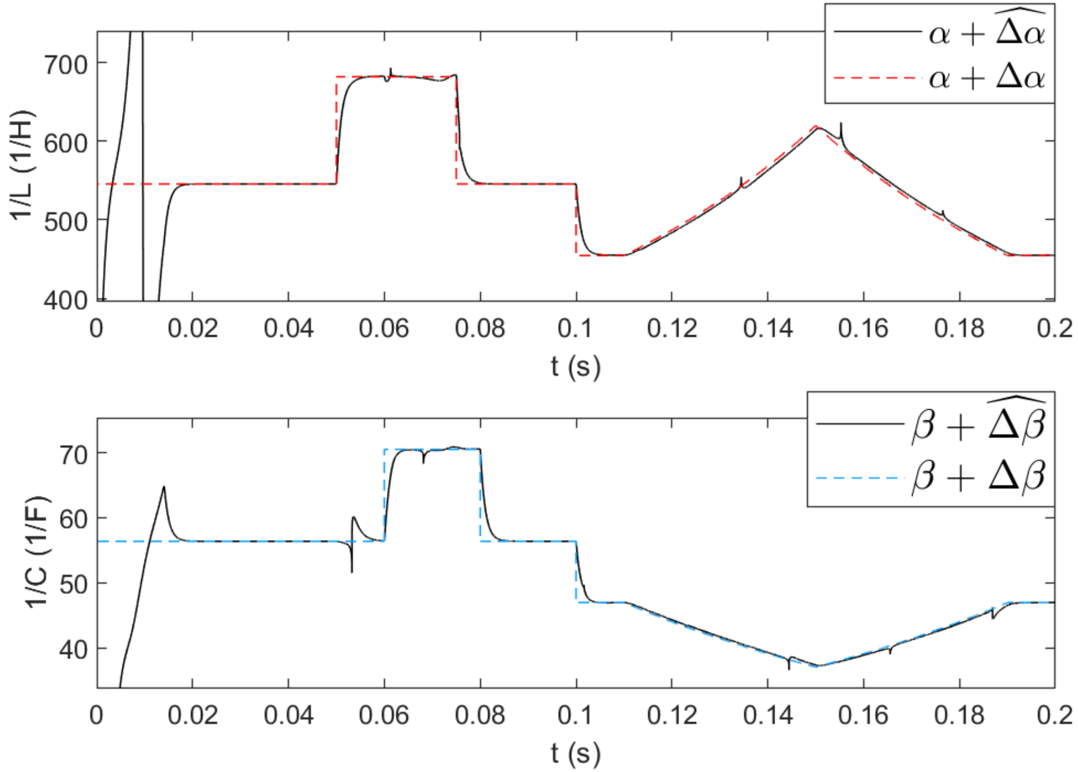
$$\dot{x}(t) = Ax(t) + Bu(t) + M(x,u)f(t)$$
$$y(t) = Cx(t)$$



$$\hat{f}_v(t) =: \left(M_2^T M_2\right)^{-1} M_2^T T^T P_o^{-1} \nu_{eq}$$

$$\hat{f}(t) = N(x,u)^{-1} \hat{f}_v(t)$$

5. Non-Linear Extention: Takagi-Sugeno Framework

Takagi-Sugeno Sliding Mode Observer Buck Converter Model

- State-Space Average Model

$$\dot{x} = \begin{bmatrix} 0 & -\frac{1}{L} \\ \frac{1}{C} & -\frac{1}{RC} \end{bmatrix} x + \begin{bmatrix} \frac{d}{L} \\ 0 \end{bmatrix} u \qquad x = \begin{bmatrix} i_L \\ V_o \end{bmatrix}$$

$$\dot{x} = \sum_{i=1}^{N} h_i(z)\,(A_i x + B_i u) \qquad \dot{\hat{x}}(t) = \sum_{i=1}^{N} h_i(z)\left(A_i\hat{x}(t) + B_i u(t) - G_{l,i} e_y(t) + G_{n,i}\nu(t)\right)$$

$$y = \sum_{i=1}^{N} h_i(z) C_i x \qquad \hat{y}(t) = \sum_{i=1}^{N} h_i(z) C_i \hat{x}(t)$$

5. Non-Linear Extention: Takagi-Sugeno Framework

Buck converter Model

- State-Space Average Model

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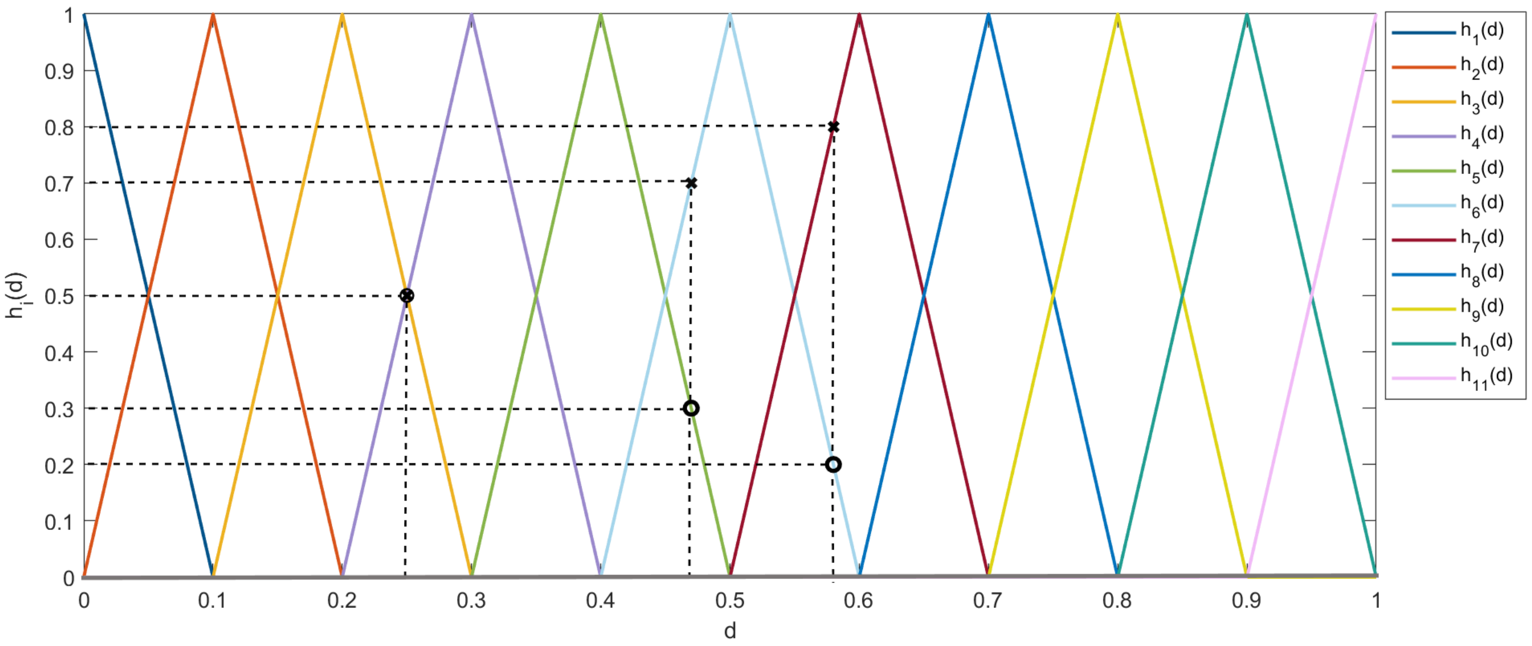

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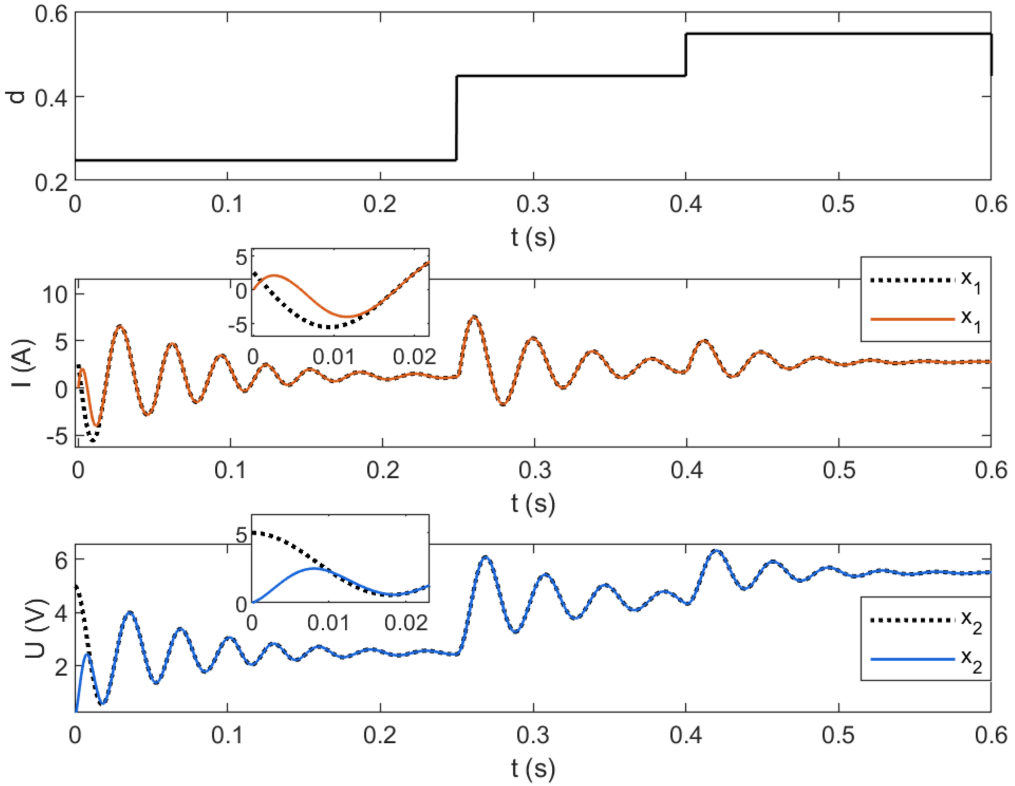
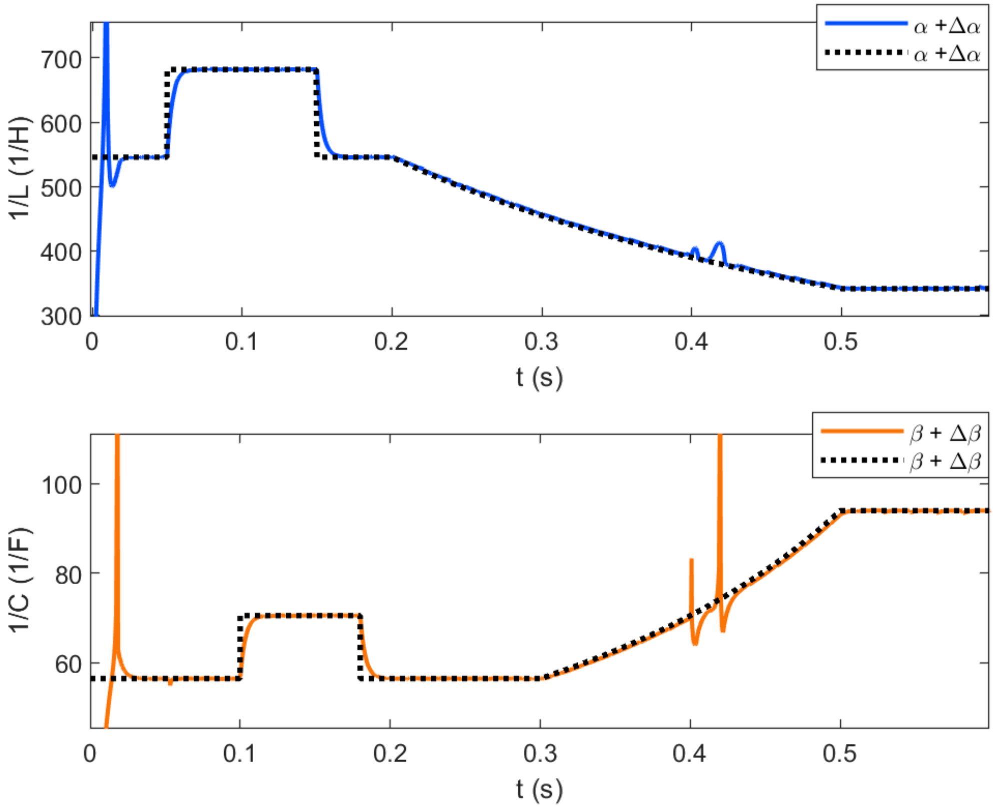
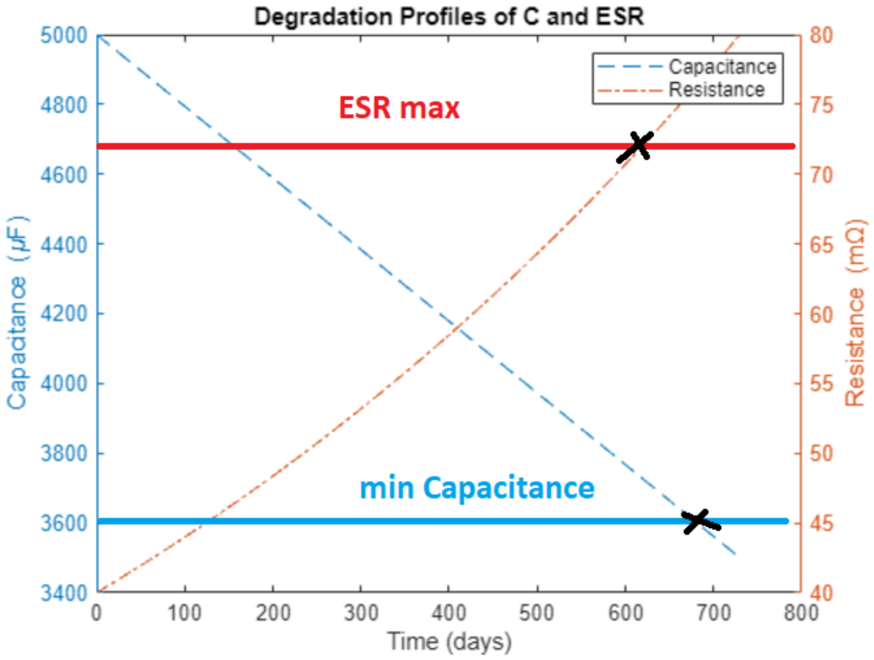
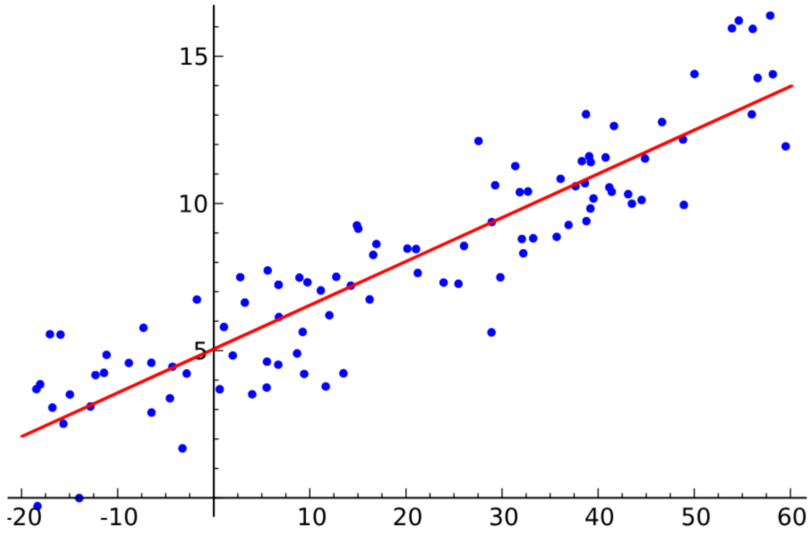




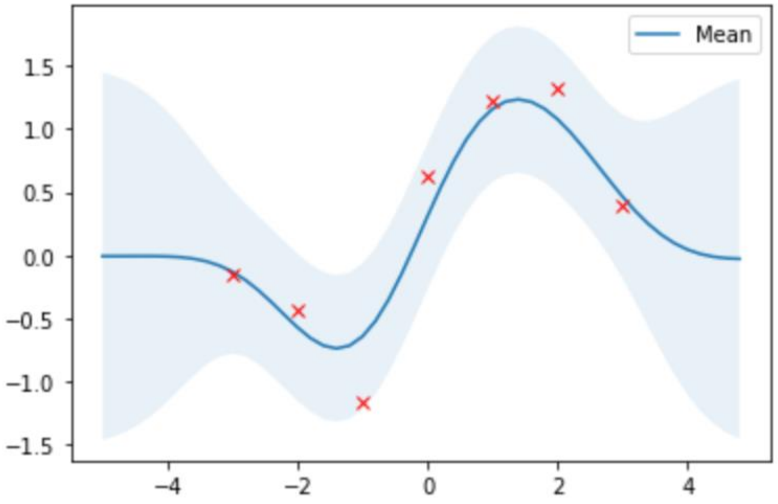
6. Outlook: Regression & Extrapolation



Matlab ex: DC Capacitor degradation



Linear regression



Gaussian Process Regression