HYDROGEN RESEARCH INSTITUTE UQTR

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World Sustainable Energy Days (WSED)

Young Energy Researchers Conference

Online Identification of a fuel cell System for Energy Management Purposes

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Fuel cells and Energy management strategy (EMS) Necessity:

Primary source:
PEMFC
- Slow dynamics
- Energy storage incapability

Secondary source:
Battery
Reduce:
- Degradation rate
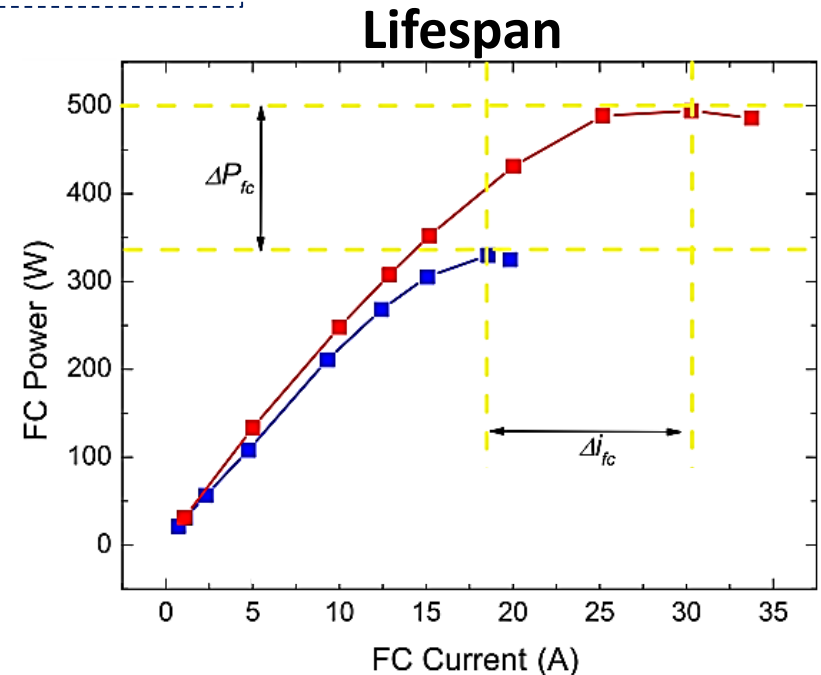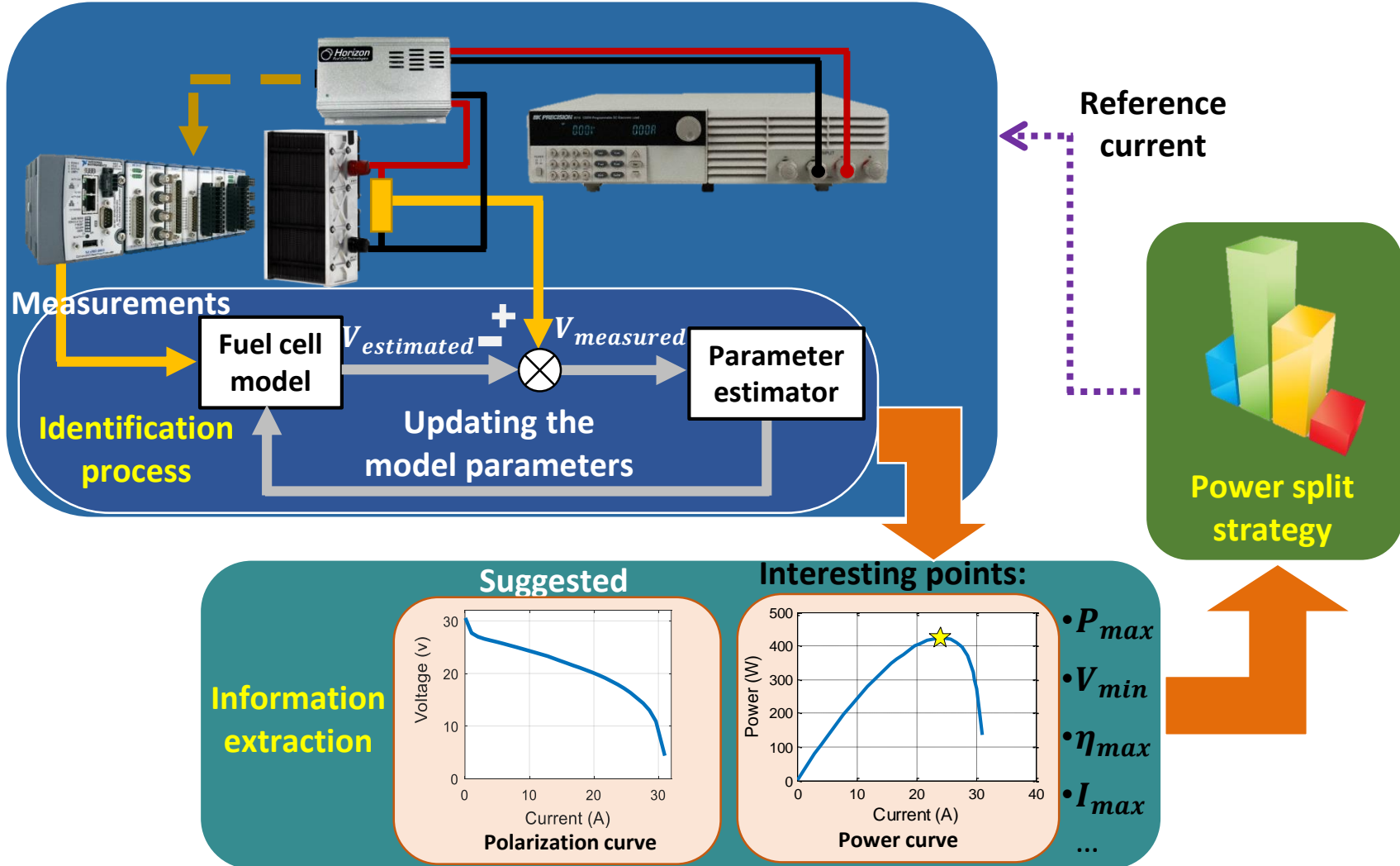- H_2 consumption

Multi-source system

EMS

Fuel Cell Complexity:

Current

Operating conditions

Pressure

Temperature

Energetic performance

Lifespan

Power curves with degradation[1]

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Global Energy Management:

Measurements

Fuel cell model

$V_{estimated}$ − + $V_{measured}$

Parameter estimator

Identification process

Updating the model parameters

Reference current

Power split strategy

Information extraction

Suggested

Interesting points:

Polarization curve

Power curve

- P_{max}
- V_{min}
- η_{max}
- I_{max}
- ...

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According to the previous work of the authors [2]:

Semi-empirical PEMFC model → Amphlett et. al

Recursive filter based methods → Kalman Filter

However, no attempt has been done regarding:

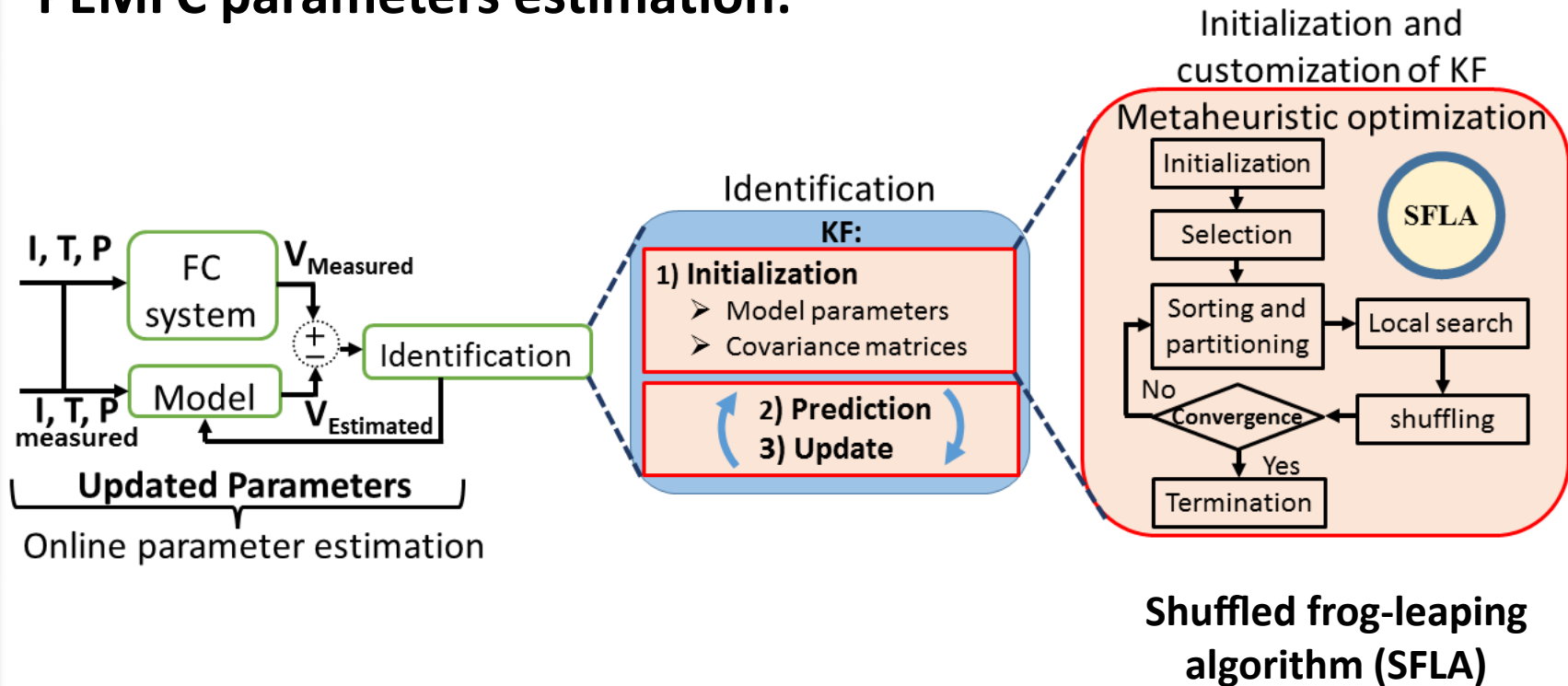Challenging initialization and customization

❖ Inappropriate initialization:

• Misinterpretation of the physical phenomena. → Results analysis

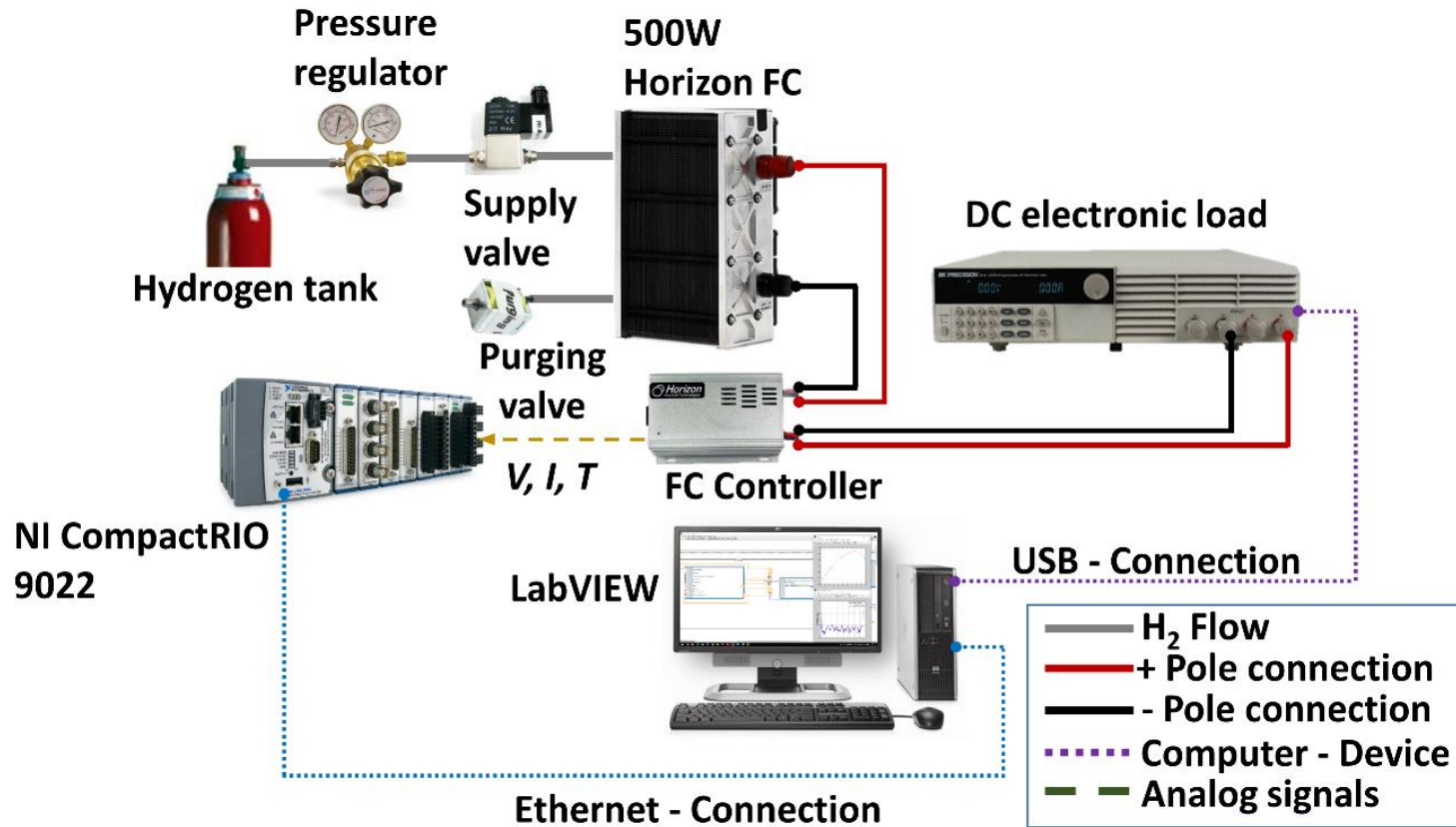• Longer prediction time. → Cold start-up application

❖ Improper customization (Q, R):

• Decrease the accuracy of the estimation. → All purposes

Important for:

Proposed approach:

IRH (UQTR)

Fonds de recherche
Nature et
technologies
Québec

WSED 2020

The tuning process of KF for online PEMFC parameters estimation:

Shuffled frog-leaping algorithm (SFLA)

Test bench:
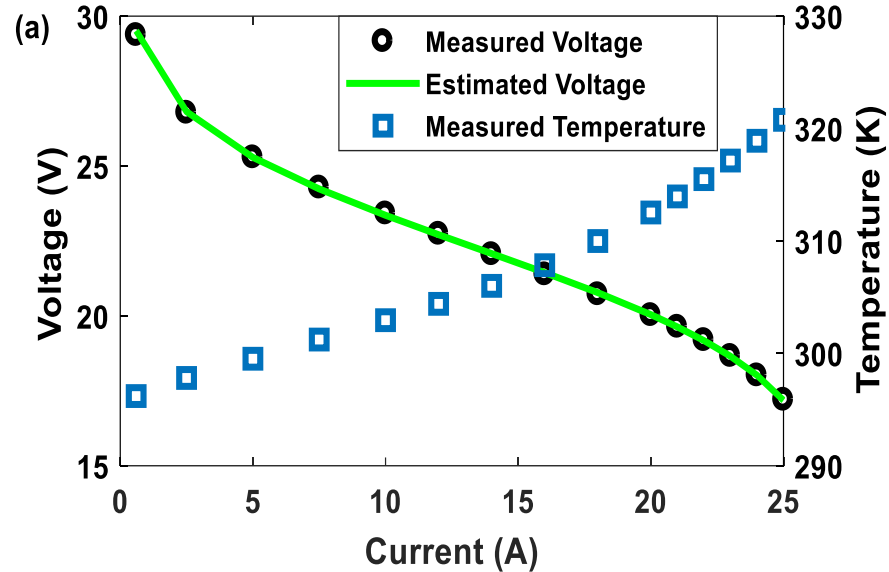

The developed test bench in Hydrogen Research Institute
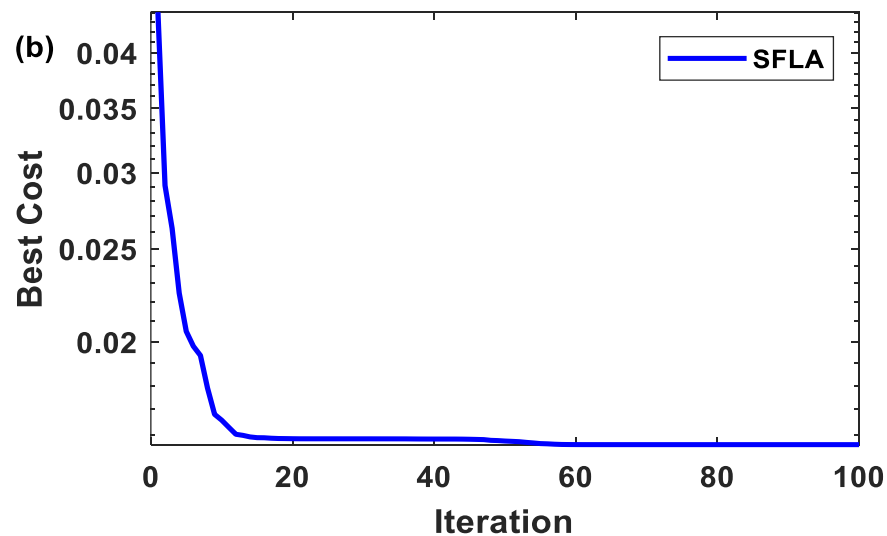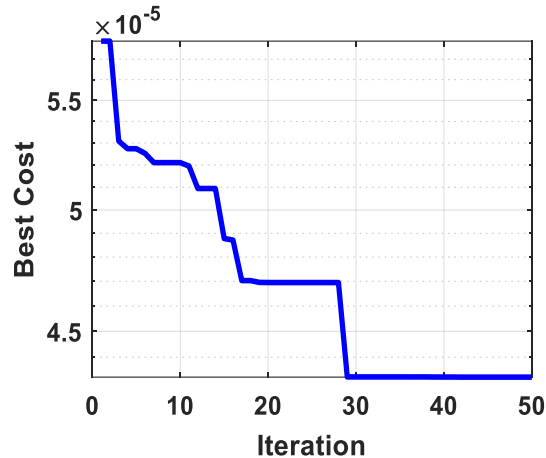
Offline initialization:
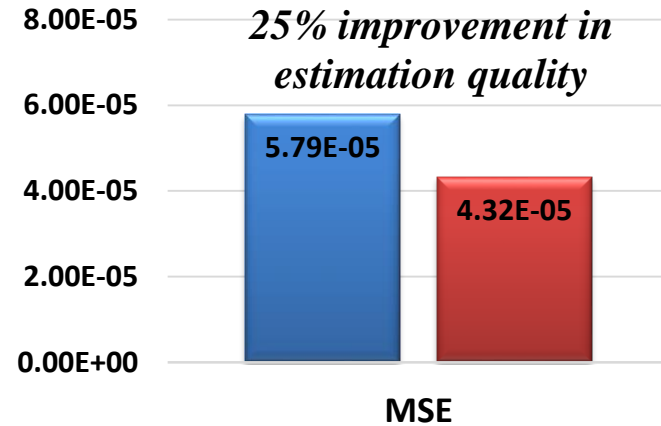
(a) 500-W Horizon PEMFC polarization curve

(b) Objective function optimization trend (SSE)

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Offline initialization:

MSE objective function minimization trend for funding Q and R matrices

25% improvement in estimation quality

5.79E-05   4.32E-05

**MSE**

■ **Before** ■ **After**

Comparison of MSE of voltage estimation before and after tuning of Q and R matrices

The obtained parameters after the tuning process

Optimization process	Obtained value	Minimum value	Maximum value
First optimization	ξ_1 = -1.1316	-1.2	-0.80
	ξ_2 = 2.603e-3	1e-3	5e-3
	ξ_3 = 5.859e-5	3.6e-3	9.8e-3
	ξ_4 = -9.04e-5	-2.6e-4	-0.954e-4
	$R_{internal}$ =0.18	0.16	0.22
	B = 0.155	0.0135	0.5
Second optimization	Q = 0.00536	1e-15	100
	R =84.38112	1e-15	100

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Online estimation:

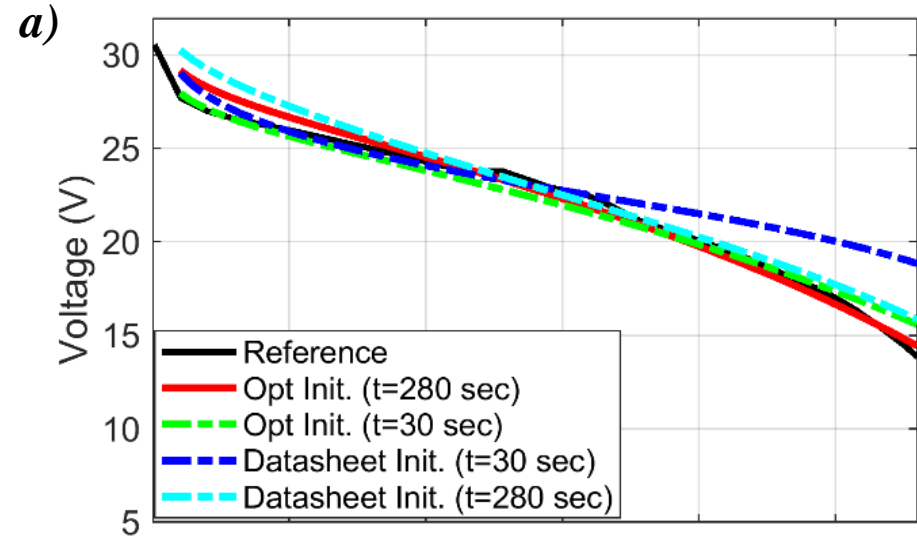*a) Current profile and stack temperature variation*
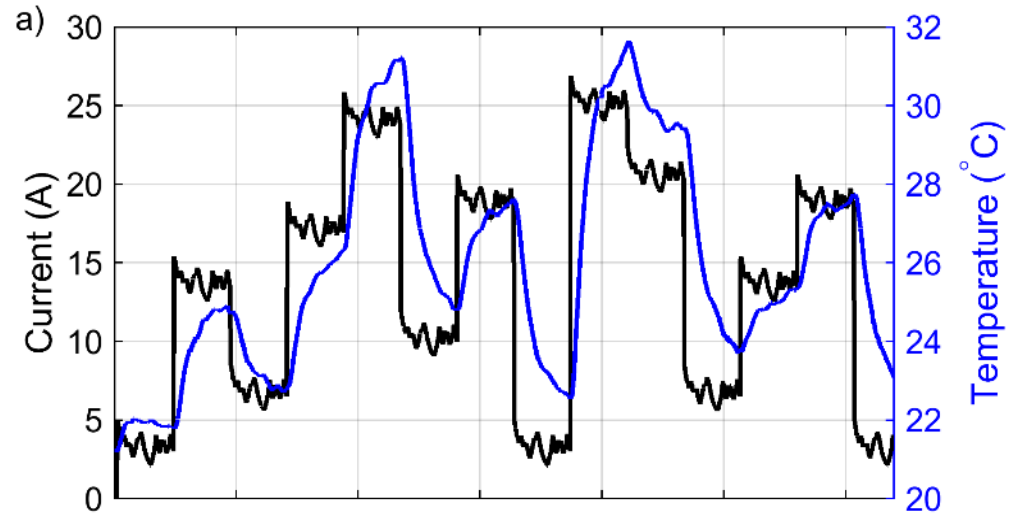
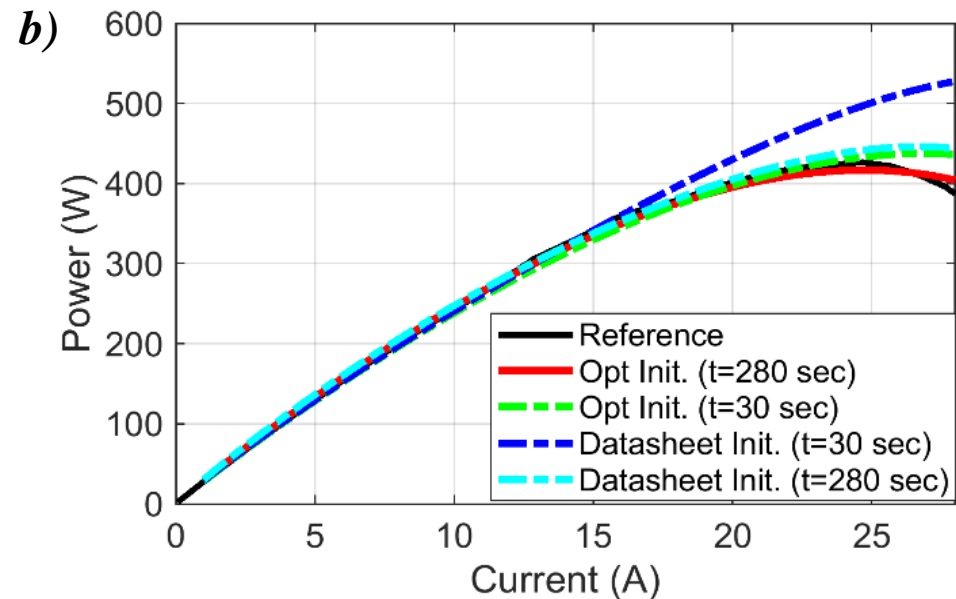*b) Voltage estimation by KF*
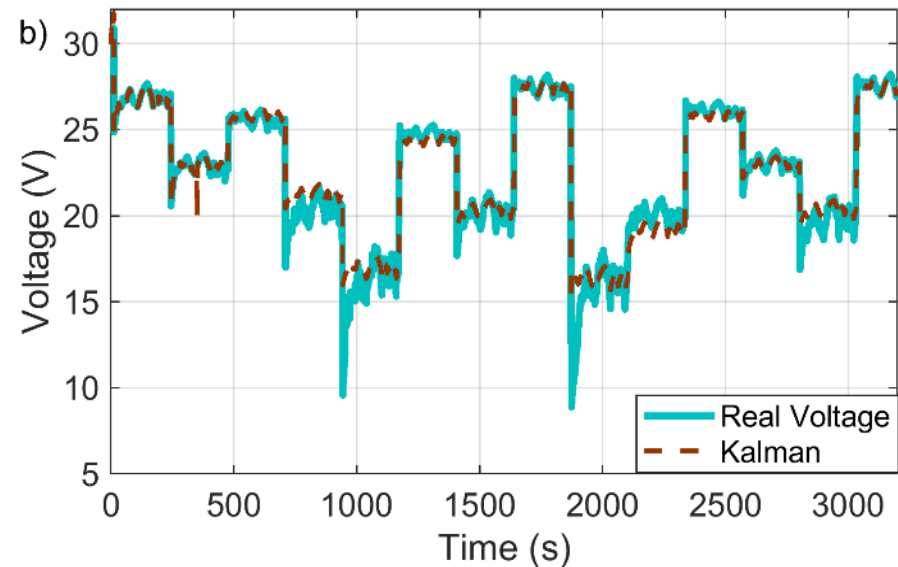
Online estimation:

a) *Polarization curve estimation*

b) *Power curve estimation*

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In this work:

| SFLA algorithm | → | Initialization Stage | → | Online parameter estimation |

Two steps:

➢ Finding the right primary values for the PEMFC model parameters.

➢ Tuning the values of R and Q covariance matrices of the KF.

Achievements:

➢ PEMFC characteristics estimation in a shorter time.

➢ Enhancement of the estimation accuracy to a certain level

Future direction:

In future, the provided basis in this work can be utilized in applications where a fast performant identification is required. One of the good examples could be developing an **adaptive cold start-up strategy** for the PEMFC stack.

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[3]   M. Kandidayeni, A. Macias, A. A. Amamou, L. Boulon, and S. Kelouwani, "Comparative Analysis of Two Online Identification Algorithms in a Fuel Cell System," Fuel Cells, vol. 18, pp. 347-358, 2018.

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[10]   S. Yang, R. Chellali, X. Lu, L. Li, and C. Bo, "Modeling and optimization for proton exchange membrane fuel cell stack using aging and challenging P systems based optimization algorithm," *Energy,* vol. 109, pp. 569-577, 2016.

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Thanks for your attention

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