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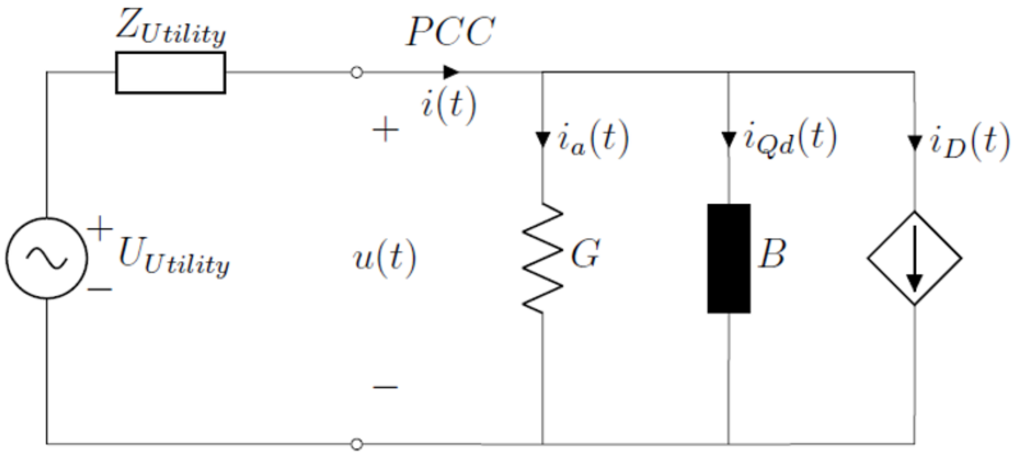
Assignment of Responsibilities for Power Quality Stationary Disturbances in Islanded Microgrids

SICEL, October 14th, 2021

Content

THEORETICAL BACKGROUND AND INTRODUCTION OF INDICES



$$P = \frac{1}{kT}\int_{\tau}^{\tau+kT} i(t)u(t)dt = \frac{1}{kT}\int_{\tau}^{\tau+kT} p(t)dt$$

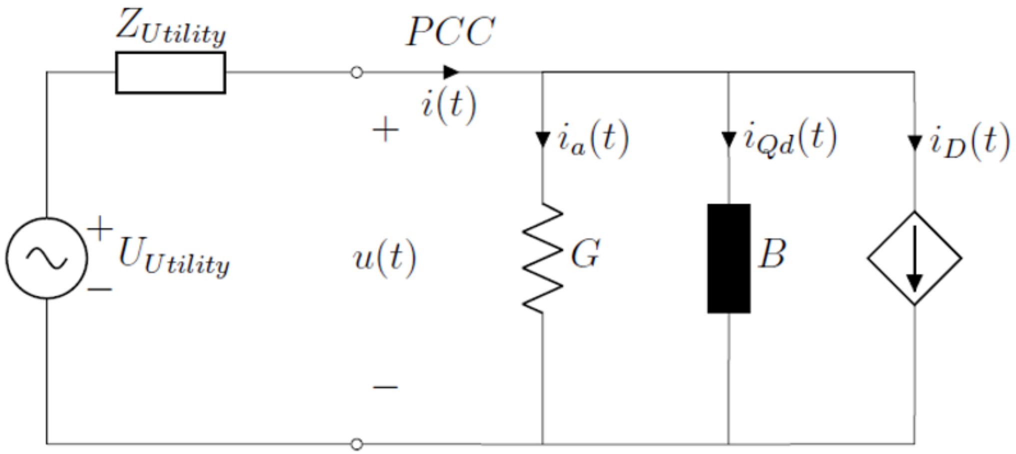
$$u(t) = U_0 + \sqrt{2}U_1 sin(\omega_1 t + \alpha_1) + \sqrt{2}\sum_{h=2}^{H} U_h sin(h\omega_1 t + \alpha_h)$$

$$i(t) = I_0 + \sqrt{2}I_1 sin(\omega_1 t + \beta_1) + \sqrt{2}\sum_{h=2}^{H} I_h sin(h\omega_1 t + \beta_h)$$

$$G = P/U^2$$

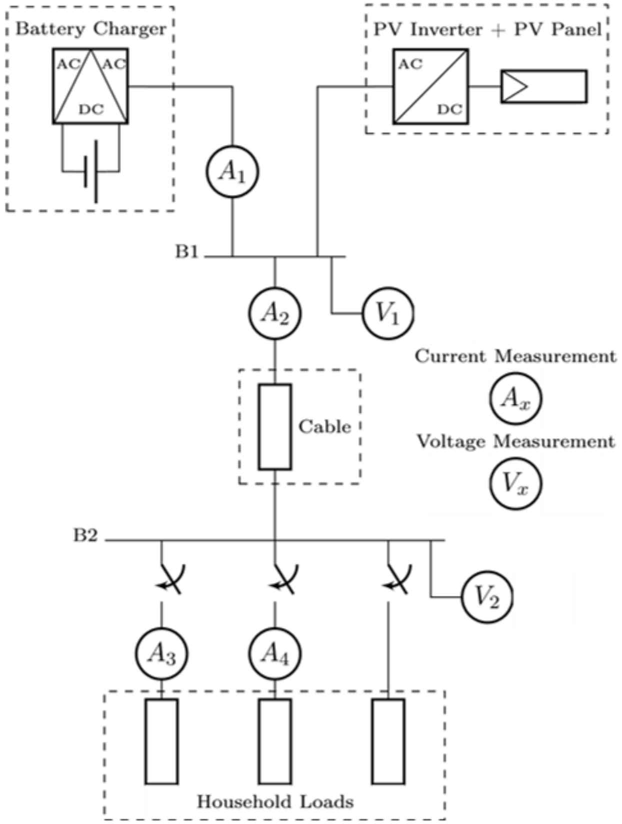
$$i_a(t) = Gu(t) = \frac{\langle i(t), u(t)\rangle}{U^2}u(t)$$

THEORETICAL BACKGROUND AND INTRODUCTION OF INDICES



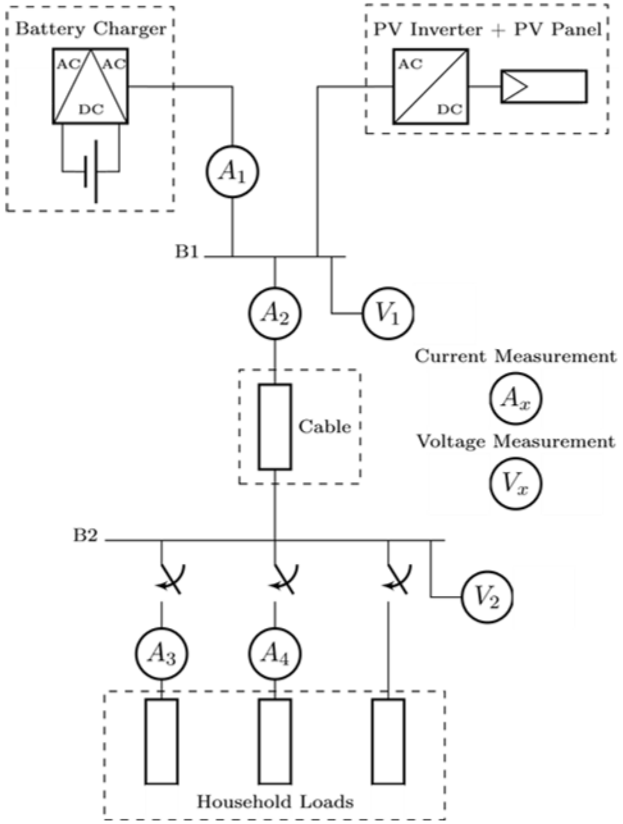
Active	$i_a(t) = \frac{\langle i(t), u(t)\rangle}{U^2} u(t)$	$P = \langle i(t), u(t)\rangle$
Non-active	$i_x(t) = i(t) - i_a(t)$	
Phase Displacement	$i_{qd}(t) = \frac{\langle i_x(t), u_d(t)\rangle}{U^2} u_d(t)$	$Q_d = \langle i_x(t), u_d(t)\rangle$
Distortion	$i_D(t) = i_x(t) - i_{qd}(t)$	$D = I_D U$

MEASUREMENT FRAMEWORK



Appliances		Available Devices	Topology and Rated Power per Device [kW]			Total Rated Power per appliance [kW]
			Linear	N-PFC	APFC	
Small kitchen appliances	Water heater	2	2			4
Office	Desktop computer	2			0.1	0.2
	Laptop	3		0.1		0.3
Lighting	Incandescent lamps	5	0.06			0.3
	CFL ≤ 25W			0.4		0.4
	CFL > 25W				0.1	0.1
Total Available Load per Topology			4.3	0.7	0.3	5.3

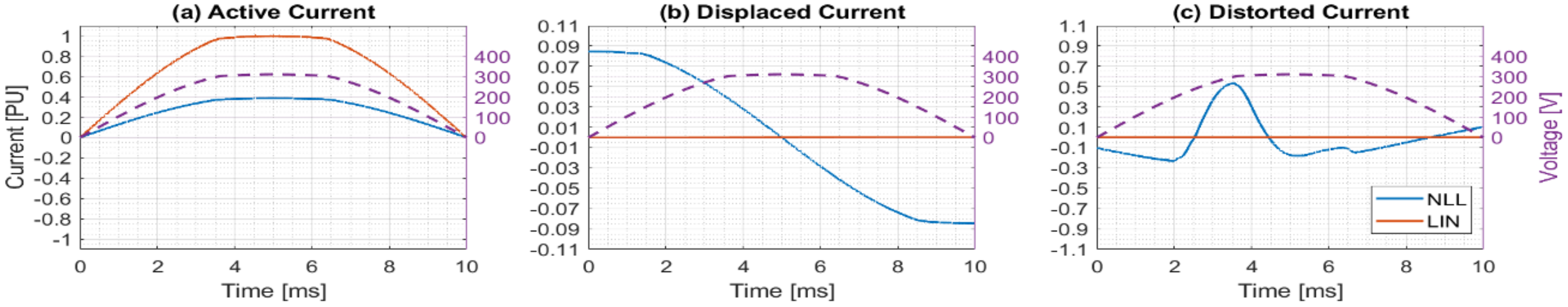
MEASUREMENT FRAMEWORK



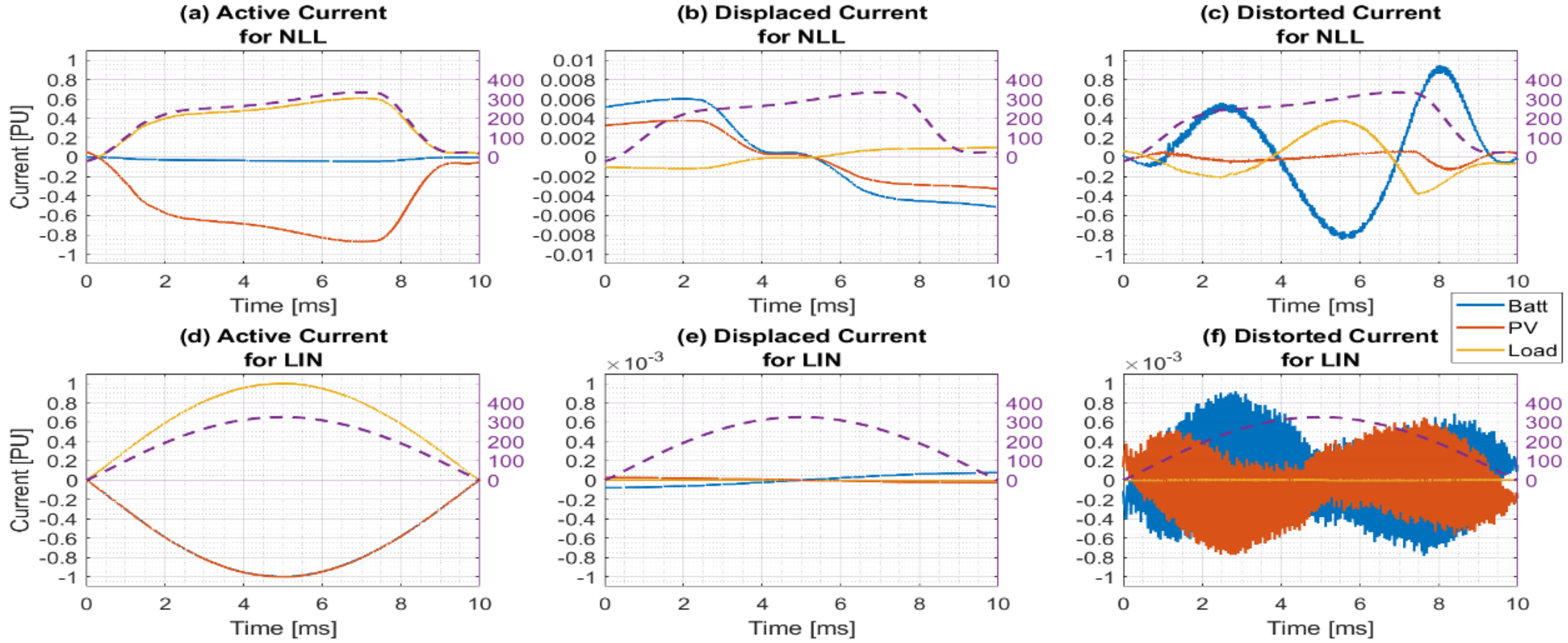
	ISM [VA]			ICM [VA]
	Battery	**PV**	**Load**	**Grid/Load**
Non-linear 1	599.94	535.29	794.70	1,061.22
Non-linear 2	339.18	0.53	338.65	336.41
Linear	1,030.62	1,174.50	2,204.84	2,143.82
Mix	2,128.11	1,188.49	3,257.11	3,174.35

DECOMPOSITION OF CURRENTS

ICM



ISM



RESPONSIBILITIE ASSIGNMENT BY MEANS OF THE METHOD OF DISTURBANCES INTERACTION

$$\begin{bmatrix} I_{Load}^2 & \pm\langle i_{Load}, i_{Battery}\rangle & \pm\langle i_{Load}, i_{PV}\rangle \\ \pm\langle i_{Battery}, i_{Load}\rangle & I_{Battery}^2 & \pm\langle i_{Battery}, i_{PV}\rangle \\ \pm\langle i_{PV}, i_{Load}\rangle & \pm\langle i_{PV}, i_{Battery}\rangle & I_{PV}^2 \end{bmatrix}$$

$$\eta_a = \begin{bmatrix} \mathbf{6.9688} & -1.3963 & -5.5725 \\ -1.3963 & 0.2798 & 1.1165 \\ -5.5725 & 1.1165 & 4.4560 \end{bmatrix}$$

$$\eta_D = \begin{bmatrix} 4.4228 & -4.9946 & 0.5718 \\ -4.9946 & \mathbf{6.2797} & -1.2851 \\ 0.5718 & -1.2851 & 0.7132 \end{bmatrix}$$

- Negative values: The compared elements interact **one against the other**.
- Positive values: Both compared elements interact **against a third one**.
- **Zero value:** There is **no interaction** between the compared elements.

Interaction Group	Element	I_D^2	I_D	% Participation
α	Load	4.4228	2.1030	83.92%
	PV	0.7132	0.8445	33.70%
β	Battery	6.2797	2.5059	100%

CONCLUSIONS

- This current decomposition allowed to decouple the impact of background distortion, namely the distorted current component from the active and displaced current components, which are driven by the background distortion.
- The method of disturbance interaction sorts the elements connected to the PCC into two groups (α and β) equally responsible. Then, it is possible to establish the contribution of each element to the group, resulting in a higher responsibility of the load in the group α and all the responsibility of the battery converter in the group β .

Thank you for your attention

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