HARMONIC - ENHANCED GENERIC LOAD MODELLING USING HARMONIC PROFILES

1. Project objectives

Scope of HARMONIC is to propose an online and event-oriented identification and generic modelling procedure using measurements.

Special emphasis is given on the data pre-processing techniques to improve the quality of the recorded signals. Different types of processing, filtering and smoothing techniques are considered and their impact on the derived network model parameters is investigated.

Additionally, a new robust generic modelling methodology is developed to derive generic dynamic models for the accurate simulation of distribution networks under different operating conditions. The application of different techniques, e.g. statistical analysis, clustering, artificial neural networks (ANN), etc. is combined with network disaggregation procedures.

More specifically, the main features and targets of the proposed research project are:

- to conduct experiments in distribution networks, consisting of loads and distributed generation (DGs);
- to develop an integrated tool suitable for the online and event-oriented identification of load models.
- to investigate the effect of data processing, filtering and smoothing techniques on the developed load models and their subsequent parameters;
- to compare different data classification approaches for generic load modelling;
- to propose a measurement-based methodology for the development of generic load models, applicable for dynamic simulations over a wide range of operating conditions. The proposed method is enhanced by the application of disaggregation techniques based on current harmonic analysis.

2. Methodology

The overall project approach includes:

- measured dynamic responses considering the active and reactive power of the examined Distribution Network and Protection (D-NAP) topologies. In this case, phasor measurements obtained at the point of common coupling (PCC) are used, considering sampling rate in the order of ms and window size of a few seconds. The test cases (TCs) include different types of scenarios, considering the operating conditions of distributed generation (DG) units and loads;
- voltage and current harmonic profile measurements at the PCC for each TC. In this case the voltage and current spectrum at the PCC is recorded, considering a time interval in the order of seconds;
- generic load model development for the dynamic simulation of distribution networks, using measurements. Typically, the dynamic responses are used to identify the network model parameters. However, in most cases the derived models are valid only for a given operating condition. Therefore, generalization techniques are examined to extend their validity for a wide range of operating conditions. This can be achieved, by means of e.g. statistical analysis or artificial intelligence (A.I.) techniques. To improve the applicability and accuracy of the developed generic models, load decomposition is adopted, based on the harmonic profile analysis.

3. Experiments

Scope of the experimental TCs is to develop generic dynamic load models, applicable to a wide range of operating conditions. This is achieved by the application of disaggregation techniques based on the analysis of current harmonic characteristics of specific groups of load and generation. More specifically, the total harmonic content of a network is decomposed into individual characteristic profiles of selected network components, e.g. motors, inverter-interfaced units, etc.. The application of disaggregation techniques provides higher visibility of the examined network mix.

Two types of experimental test configurations are conducted:

- Harmonic profile recording: Harmonic voltage and current profiles are initially recorded at each network node. Next, the aggregated (total) current harmonic profile is recorded at the point of common coupling (PCC), as shown in Fig. 1. Different types of load and generation mix are examined as described in detail in Table 1.
- Dynamic responses recording: Dynamic responses are recorded only at the PCC. Disturbances are created by properly adjusting the D-NAP Triphase, as shown in Fig. 2. The same network configurations described in Table 1 are examined also in this case.

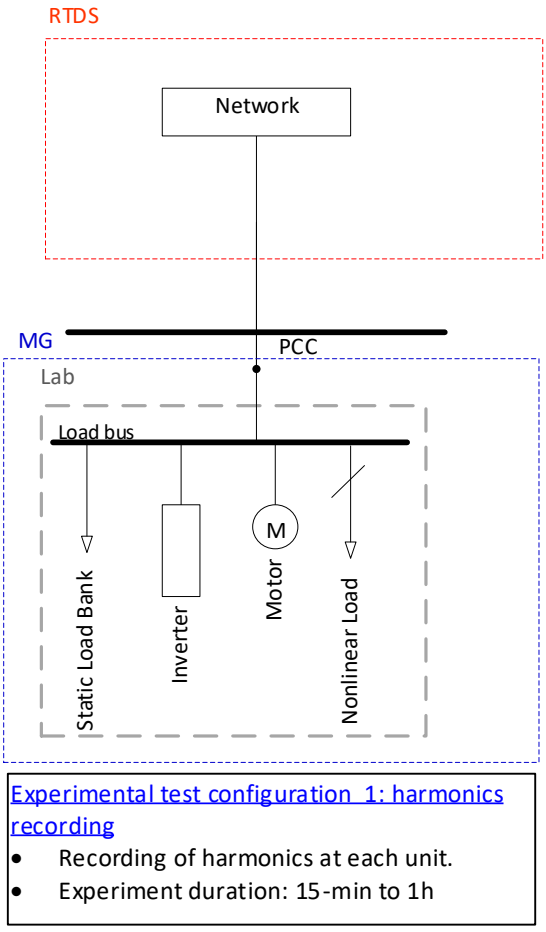

Fig. 1: Harmonic profile recording

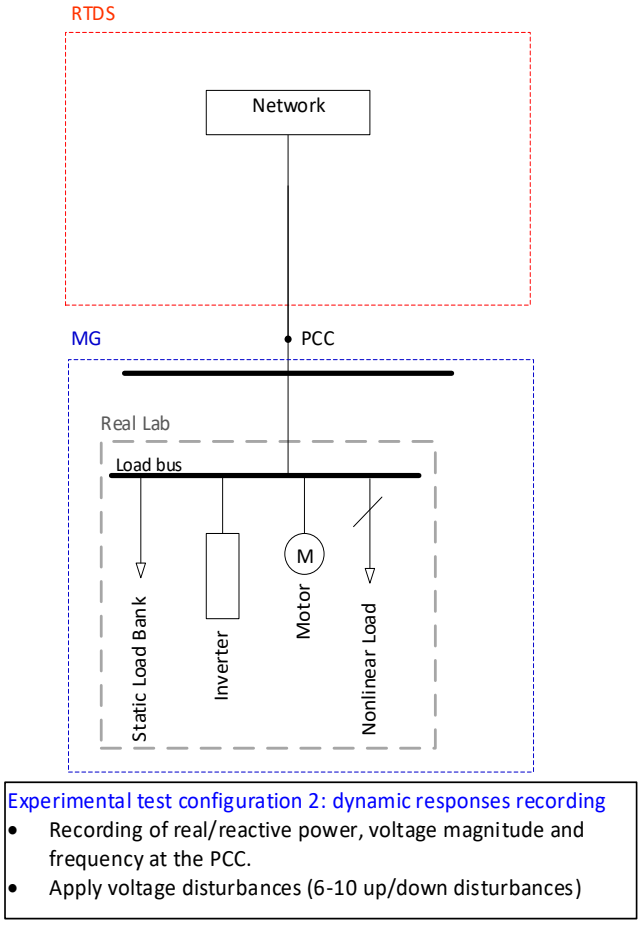

Fig. 2: Dynamic responses recording

Table 1: Experimental test configuration

Experimental test configurations						
Test Case		**Total**	**Static**	**Motor**	**Converter**	**NLL**
C1_1a	**kW**	30.5	15	5.5	6	4
	%	100	49.18033	18.03278689	19.67213115	13.11475
C1_1b	**kW**	30.5	15	5.5	4	6
	%	100	49.18033	18.03278689	13.1147541	19.67213
C1_1c	**kW**	30.5	15	5.5	8	2
	%	100	49.18033	18.03278689	26.2295082	6.557377
C1_2a	**kW**	30.5	19	5.5	2	4
	%	100	62.29508	18.03278689	6.557377049	13.11475
C1_2b	**kW**	35	19	5.5	4.5	6
	%	100	54.28571	15.71428571	12.85714286	17.14286
C1_2c	**kW**	30.5	19	5.5	6	0
	%	100	62.29508	18.03278689	19.67213115	0
C1_3a	**kW**	30.5	19	0	8	3.5
	%	100	62.29508	0	26.2295082	11.47541
C1_3b	**kW**	30.5	19	0	5.5	6
	%	100	62.29508	0	18.03278689	19.67213
C1_3c	**kW**	27	19	0	8	0
	%	100	70.37037	0	29.62962963	0
C1_4a	**kW**	35	19	5.5	5	5.5
	%	100	54.28571	15.71428571	14.28571429	15.71429
C1_4b	**kW**	35	19	5.5	8	2.5
	%	100	54.28571	15.71428571	22.85714286	7.142857
C1_4c	**kW**	35	19	5.5	4.5	6
	%	100	54.28571	15.71428571	12.85714286	17.14286
C1_5a	**kW**	20	10	5.5	2	2.5
	%	100	50	27.5	10	12.5
C1_5b	**kW**	20	5	5.5	7	2.5
	%	100	25	27.5	35	12.5
C1_5c	**kW**	19	15	0	2	2
	%	100	78.94737	0	10.52631579	10.52632

3. Summary of the results and conclusions

- Aggregated harmonic load profiles of distribution networks, including inverter-interfaced and directly connected DG units are investigated experimentally. The aggregated profiles can be decomposed into a given number characteristic current profiles, corresponding to

disnstictnetwork components, e.g. DG units. This information can be used to provide inrfomation regarding the mic of the examined network;

- Dynamic responses are recorded for different operating conditions and levels. Such measurements can be used to develop aggregated dynamic modesl;
- To analyze dynamic response, an online, event-oriented identification and modelling procedure is developed;
- A generic measurement-based modelling approach to extend the applicability of dynamic network models to a wide range of operating conditions is designed. A distinct characteristic of the proposed method is the use of disaggregation techniques to enhance network visibility and improve modelling details and accuracy on the proposed procedure;
- For the first-time harmonic profiles and dynamic responses in active distribution networks are simultaneously investigated and combined;
- Results and proposed methods will be presented in one scientific conference and will be published in one journal paper.