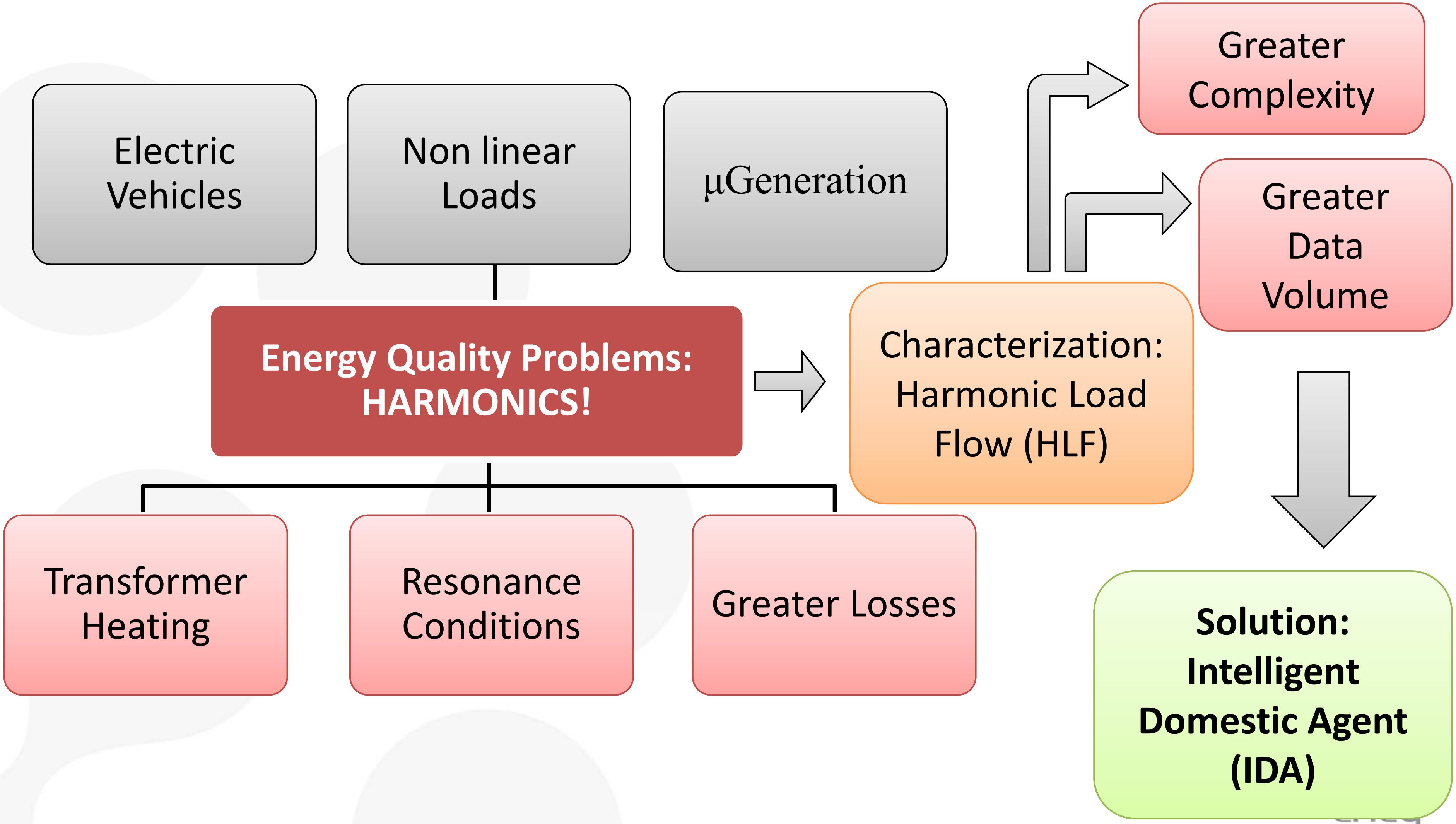
Assessment of PV and Wind Microgeneration's Impact in the Power Quality of Low and Medium Voltage Distribution Networks

Paulo Bonifácio
Luis Rodrigues, Susana Viana and Ana Estanqueiro

Contextualization



Objectives – REIVE Project:

- Analyse the Impact of Microgeneration and Electric Vehicles integration in the low voltage grid and in Power :
  - Access Total Harmonic Distortion (THD).
  - Evaluate Neutral currents.
  - LNEG: Access flicker levels and dynamic voltage profile in local distribution network.

LNEG

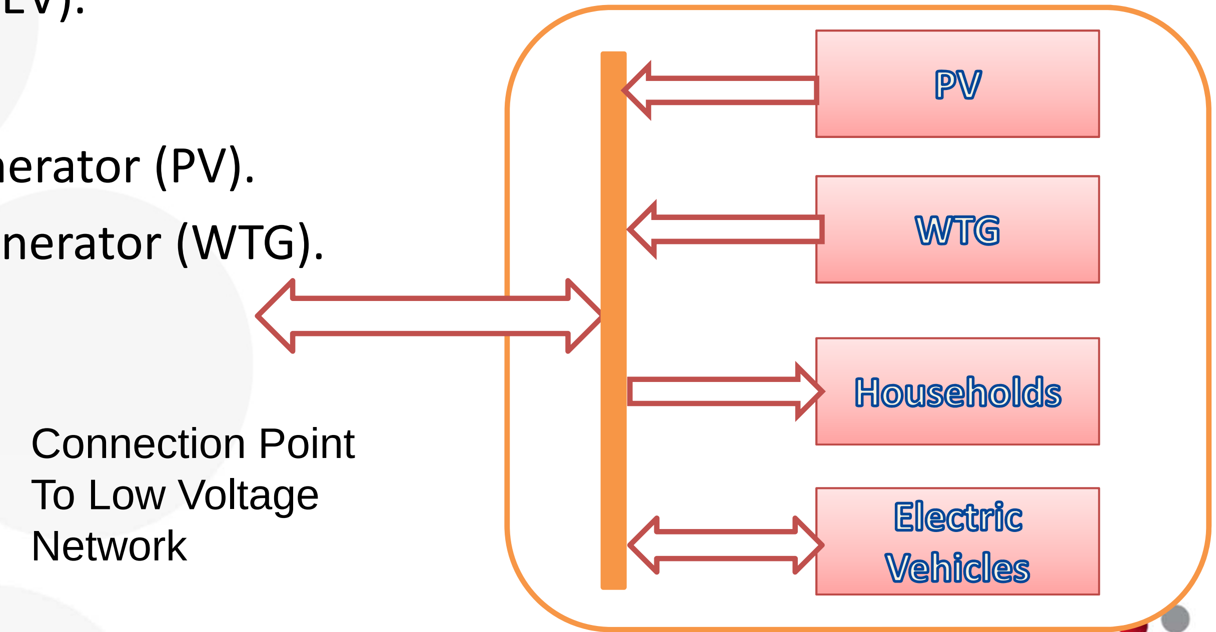
Developed Work

- Development of a Harmonic Load Flow Tool (TEH) for 3-phase Balanced networks – Matlab.
- Development of a Modular Reconfigurable Consumer Model – IDA.
- Creation of a Power Quality Assessment Tool:
    - Low Voltage 3-phase networks.
    - Balanced and Unbalanced
    - 1 & 3-phase consumers.
    - Implementation in Matlab/Simulink.

Single-Phase Domestic Load Model

Intelligent Domestic Agent – IDA :

- Household Loads (HH).
- Non Linear Loads.
  - Electric Vehicles(EV).
- Microgeneration
  - Photovoltaic Generator (PV).
  - Wind Turbine Generator (WTG).

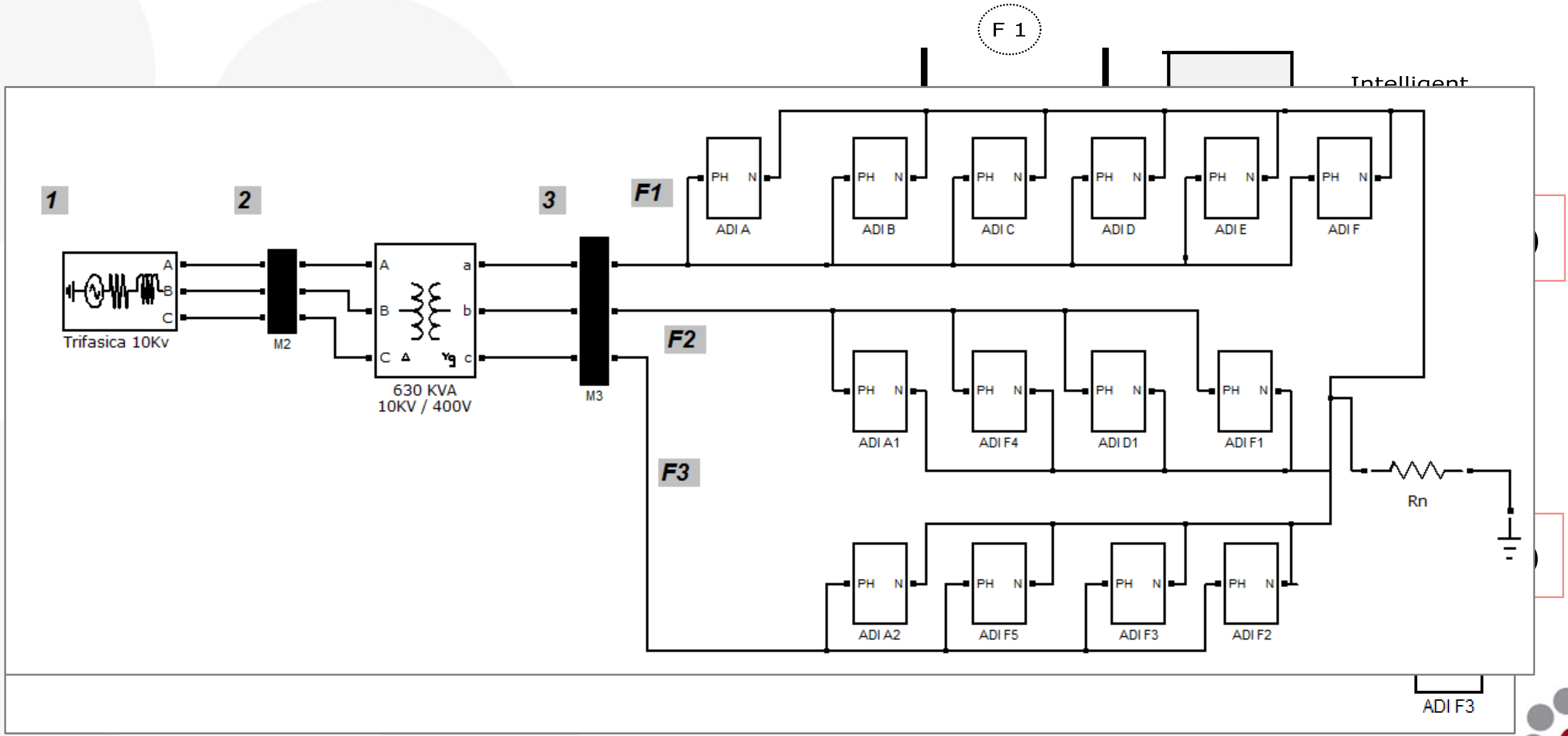


IDA - Components

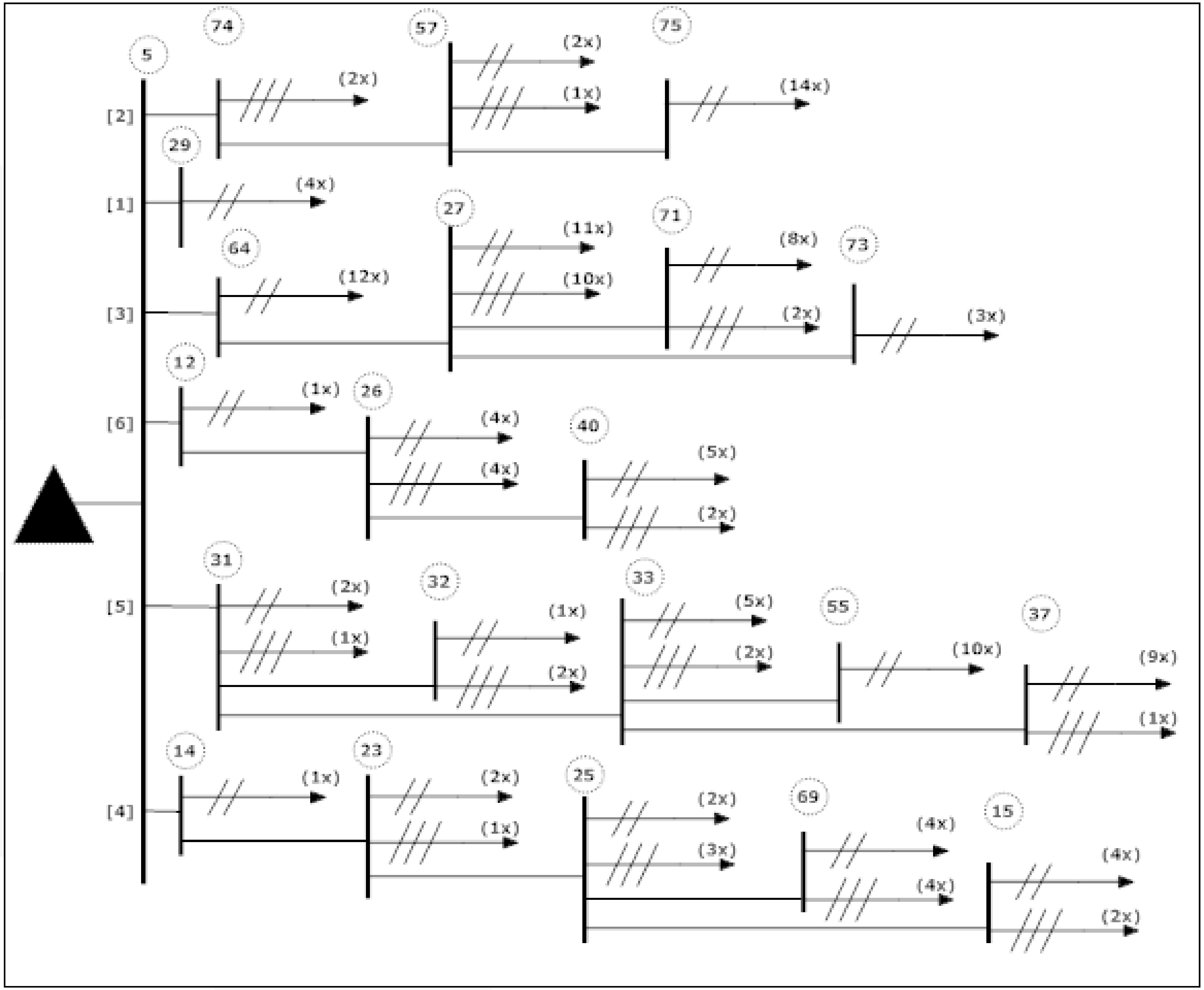
- I – Current Injection/Consumption Models
  - Fundamental and Harmonic currents represented through ideal current sources.
  - Individual Input/output current spectrum for each Power Converter connected to the grid.
- II – Physical Models
  - Modelling of the behaviour of the components with fluctuations of renewable resources.

LNEG

Model Validation – Balanced/ Unbalanced Networks



Test Network I



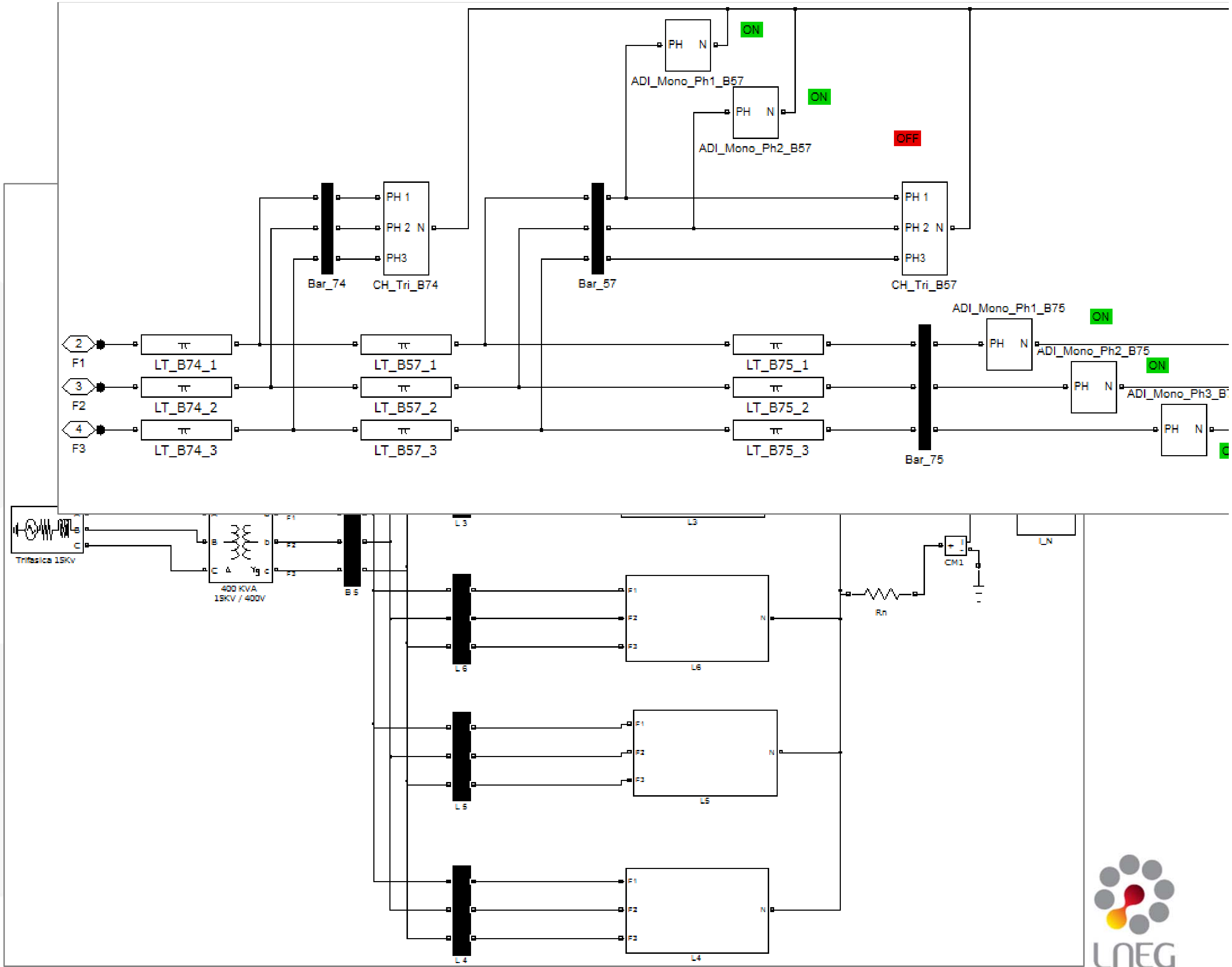
Test Network II

Challenges

- 6 lines to substation.
- 142 clients 1 or 3-phase.
- Imprecise data regarding the connection of single-phase clients.

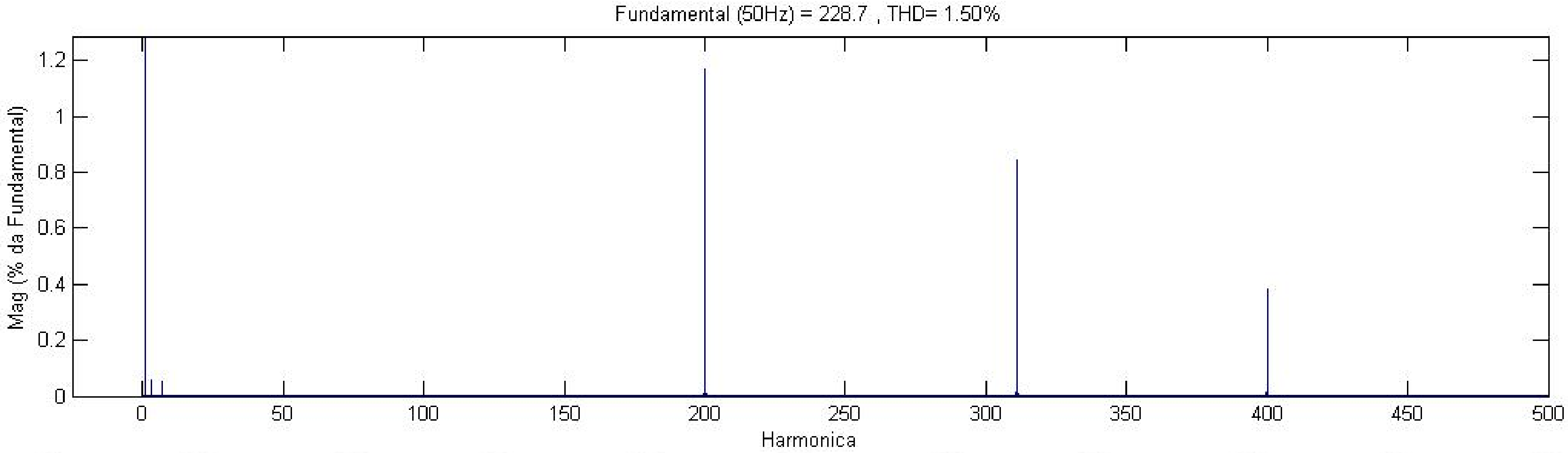
Solutions

- Aggregation of single-phase loads in a single ADI for each phase and for each bus bar.
- Aggregation of 3-phase loads in a single load for each bus bar.
- Sequential distribution of the ADIs for each line.

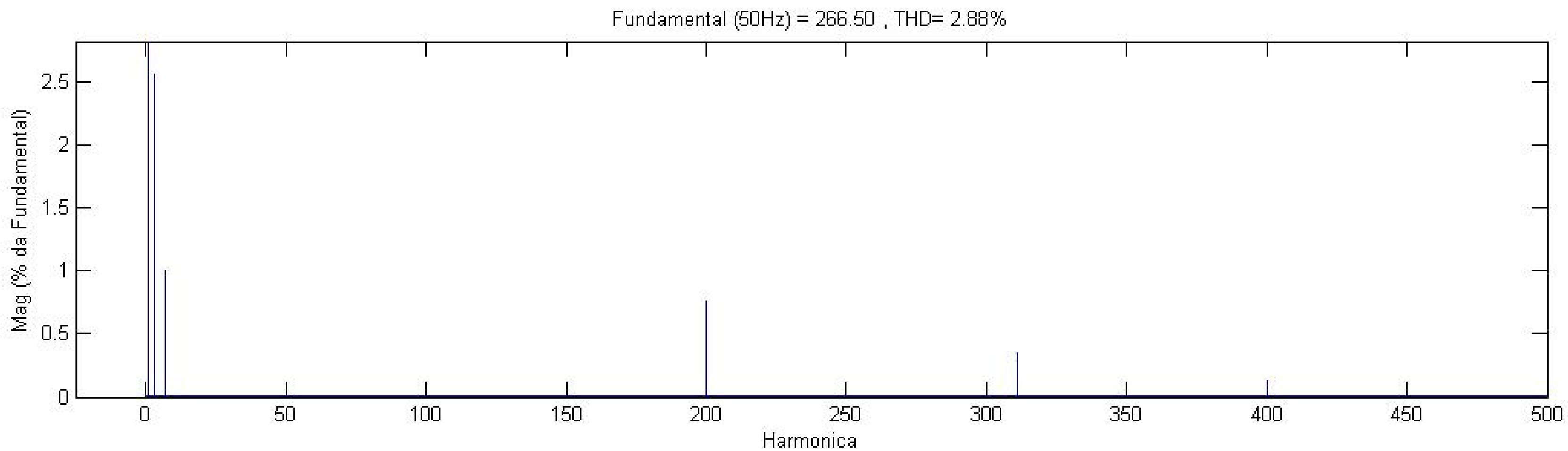

ON
ON
OFF
PH
N
ADI_Mono_Ph1_B57
ADI_Mono_Ph2_B57
PH 1
PH 2
PH3
Bar_74
CH_Tri_B74
Bar_57
CH_Tri_B57
ADI_Mono_Ph1_B75
ADI_Mono_Ph2_B75
2
3
4
F1
F2
F3
LT_B74_1
LT_B74_2
LT_B74_3
LT_B57_1
LT_B57_2
LT_B57_3
LT_B75_1
LT_B75_2
LT_B75_3
Bar_75
Trifasica 15Kv
400 KVA
15KV / 400V
Rn
CM1
L6
L5
L4

Test Methodology

Voltage FFT



Current FFT



Test Cases

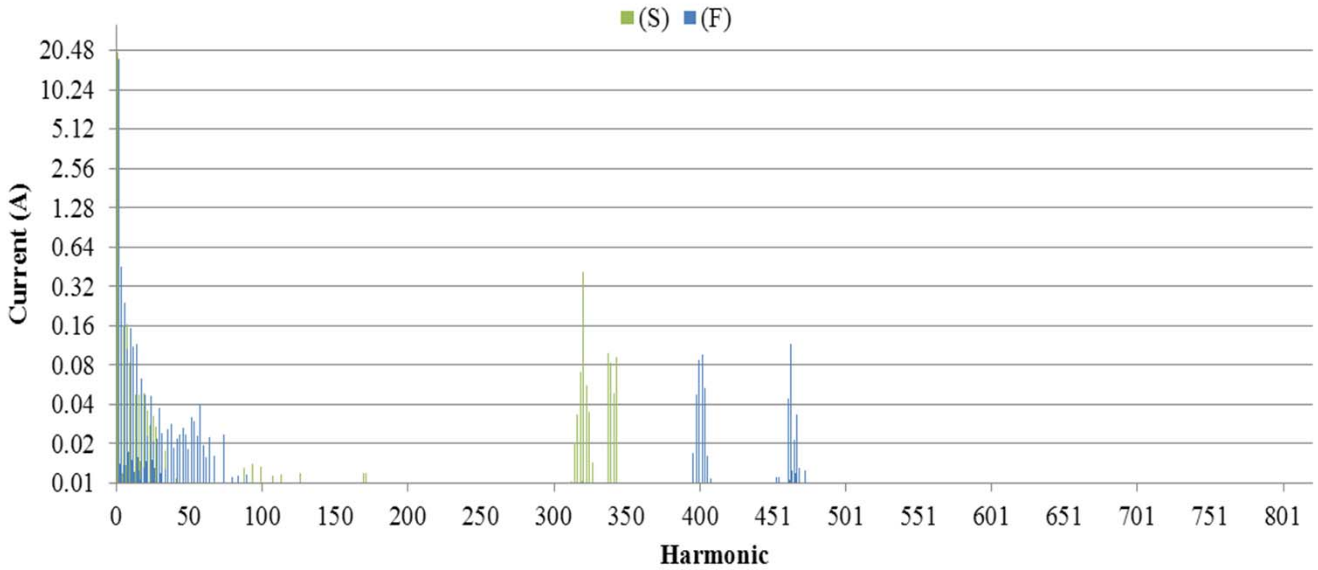
Case	Conditions
I	• Only Loads – peak cenario
II	• Loads – 25 % of peak load • Electric Vehicles – all single-phase loads
III	• Loads – 25 % of peak load • Electric Vehicles – all single-phase loads • Microgeneration – 1 source for each bus bar
IV	• Loads – 25 % of peak load • Electric Vehicles – 1 per bus • Microgeneration – all single-phase loads

LNEG

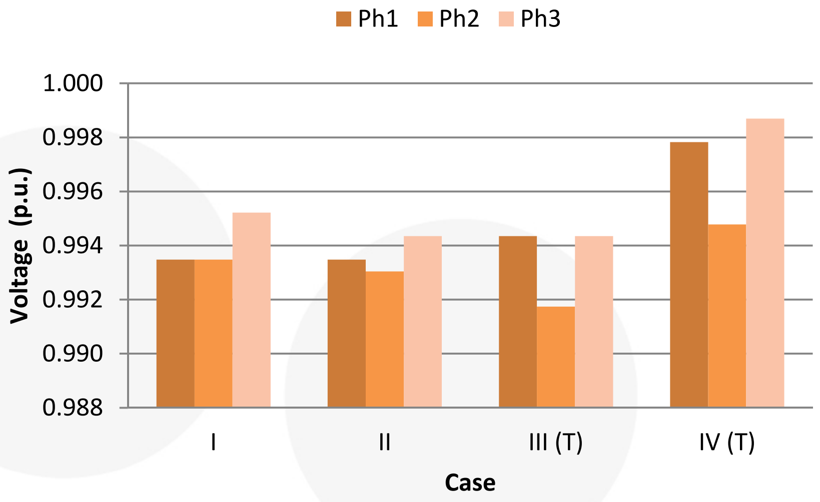
Case III and IV - Branching

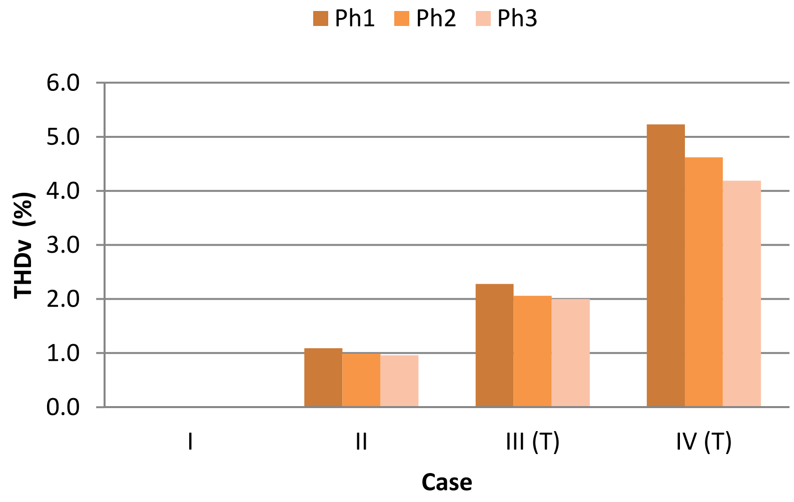
Utilization of Real World Signals Obtained form LV – PV Inverters.

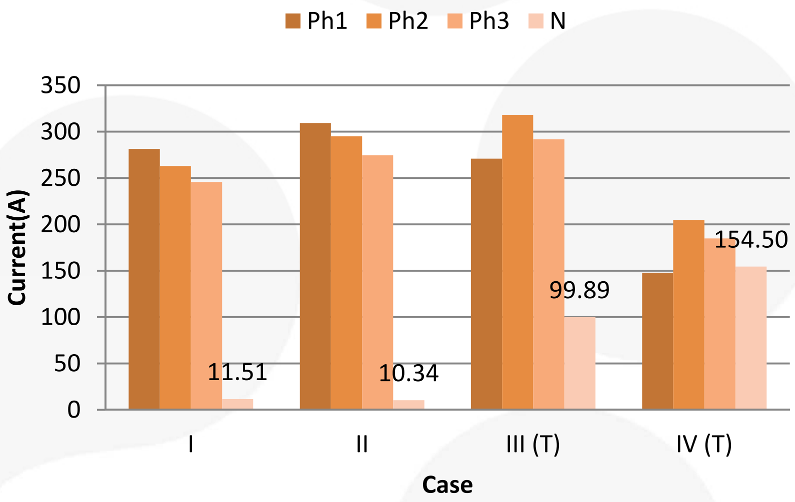
- **Cases:**
  - **(T) – Theoretical Model.**
  - **(S) – Current Model for Device 1.**
  - **(F) – Current Model for Device 2.**

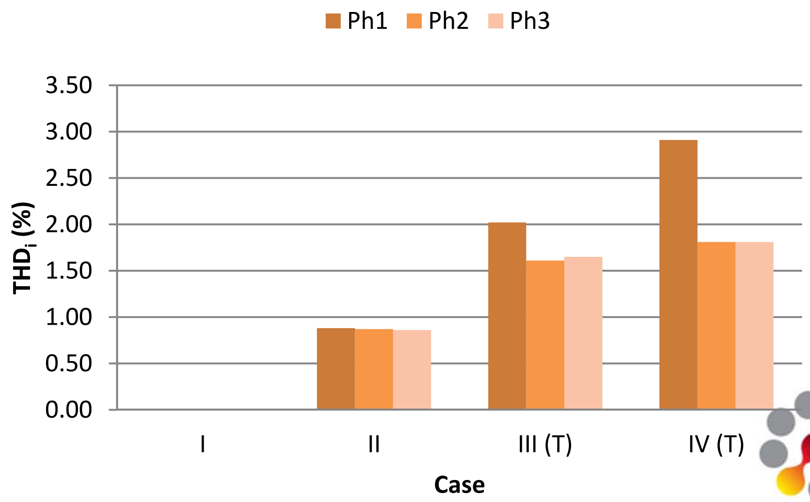


Results – Transformer (LV-Side)









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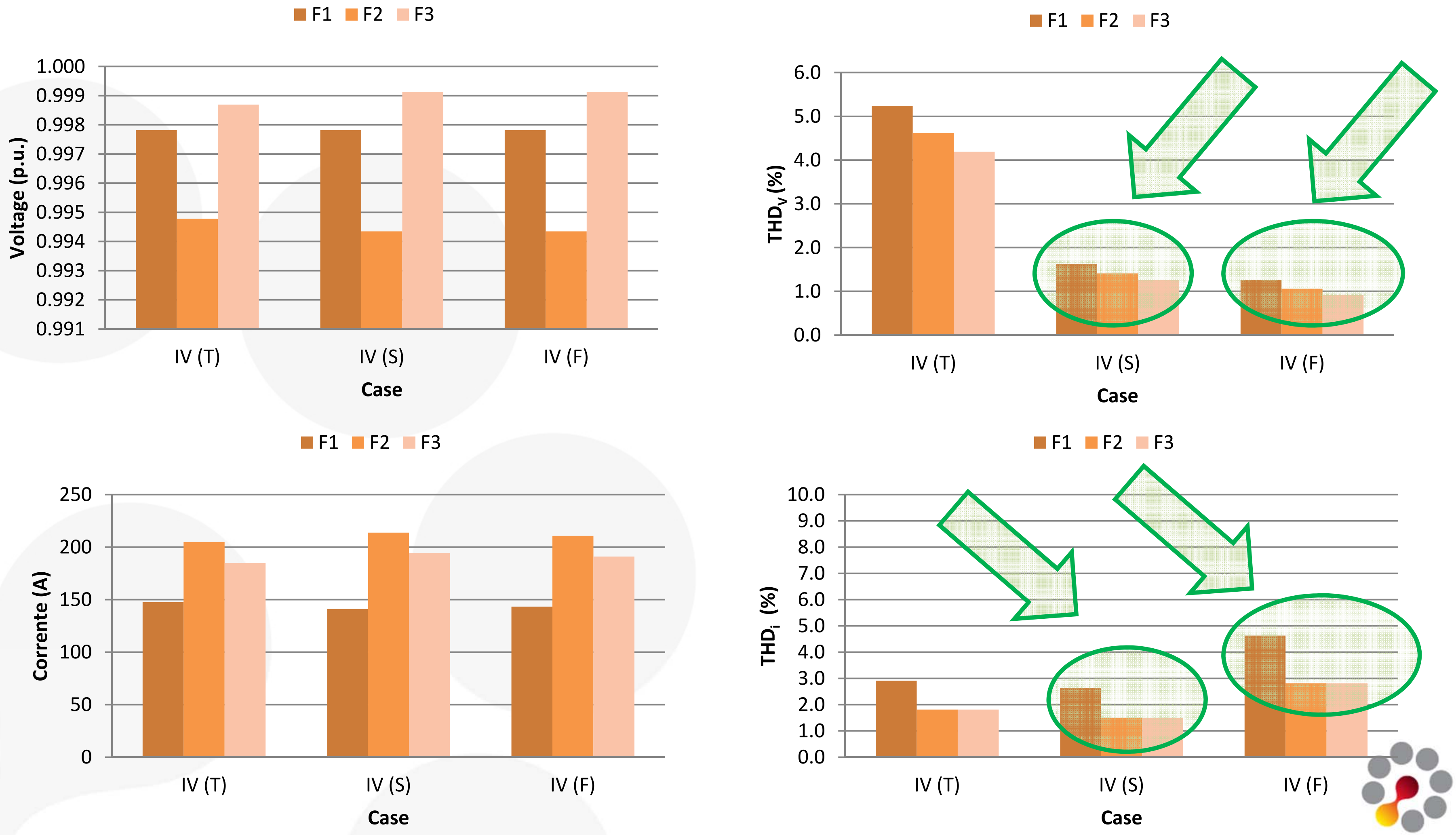
Different Device Signals



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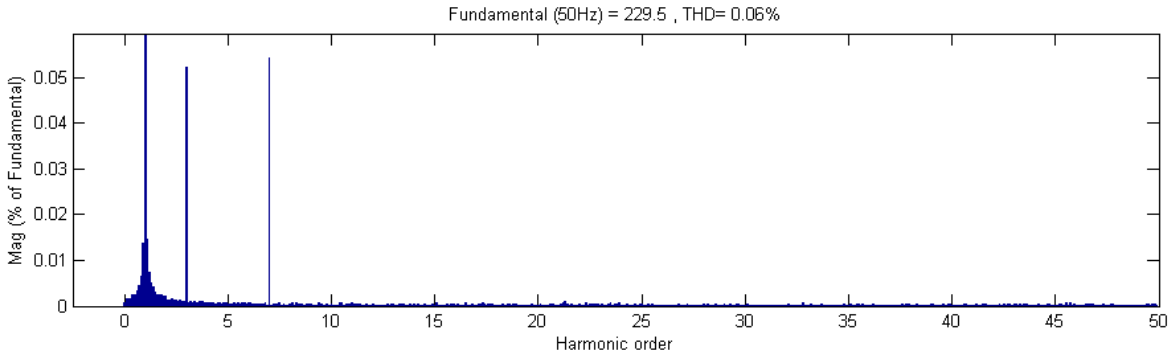
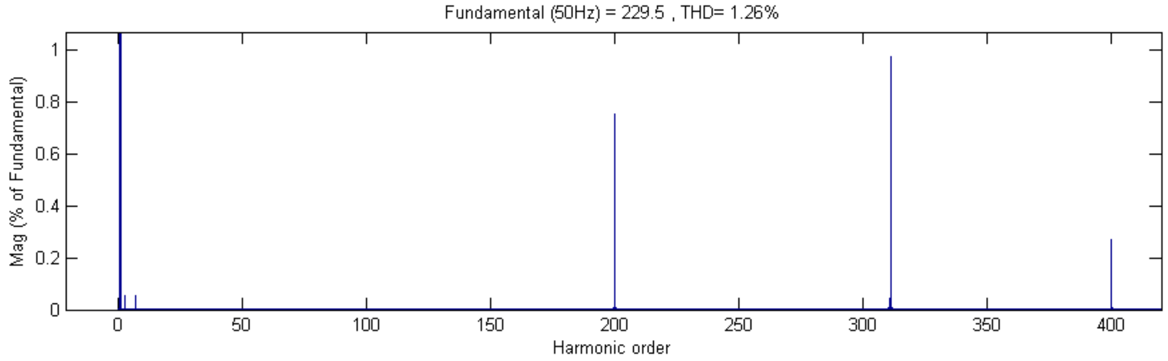
Voltage THD Comparison

THD – According to IEC 61000-2-2 – 50th Harmonic – 2500 Hz



THD – Full Harmonic Spectrum – 21 kHz



Values for Case IV(F) at Bus 5

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Conclusions

- Voltage and Current Total Harmonic Distortion Values are conforming to IEC 61000-3-2, EN50160 standards.
- Results present a significant contribution as pre-normative recommendation in considering high frequency harmonics acquired from real device measurements (f>40).

Thanks For Your Time

Laboratório Nacional de Energia e Geologia, I. P.

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