Dual-Mode Soft-Transition Control for Single-Phase Grid-Connected Photovoltaic Inverters

David Elizondo, Andoni Urtasun

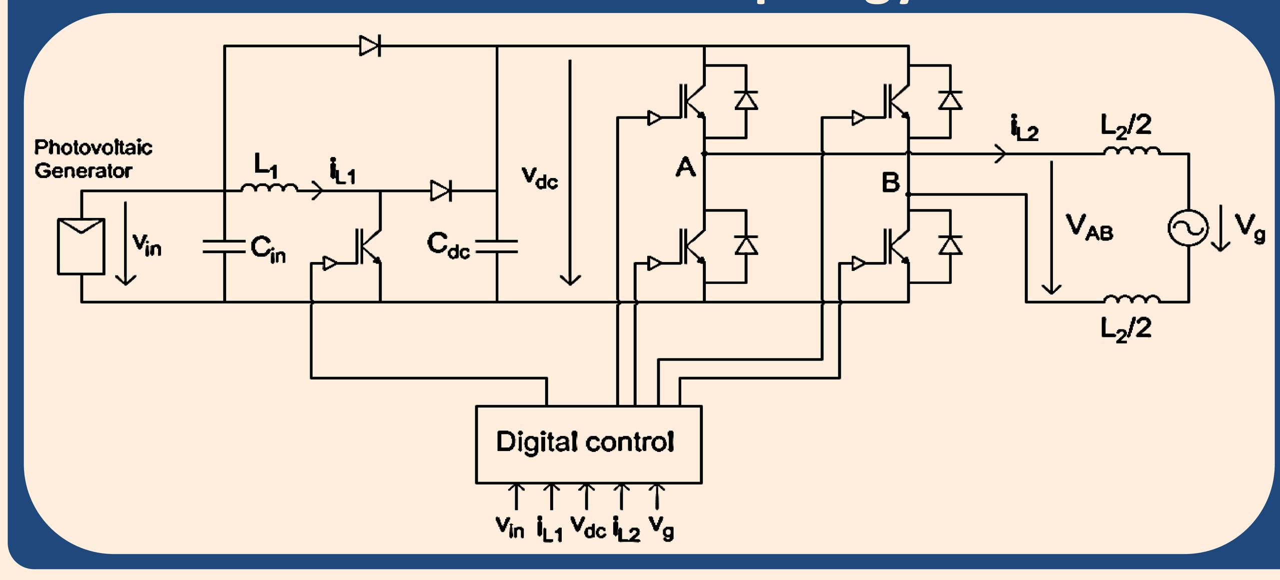
Dept. of Electrical and Electronic Engineering – Institute of Smart Cities

Public University of Navarre, Pamplona (Spain)

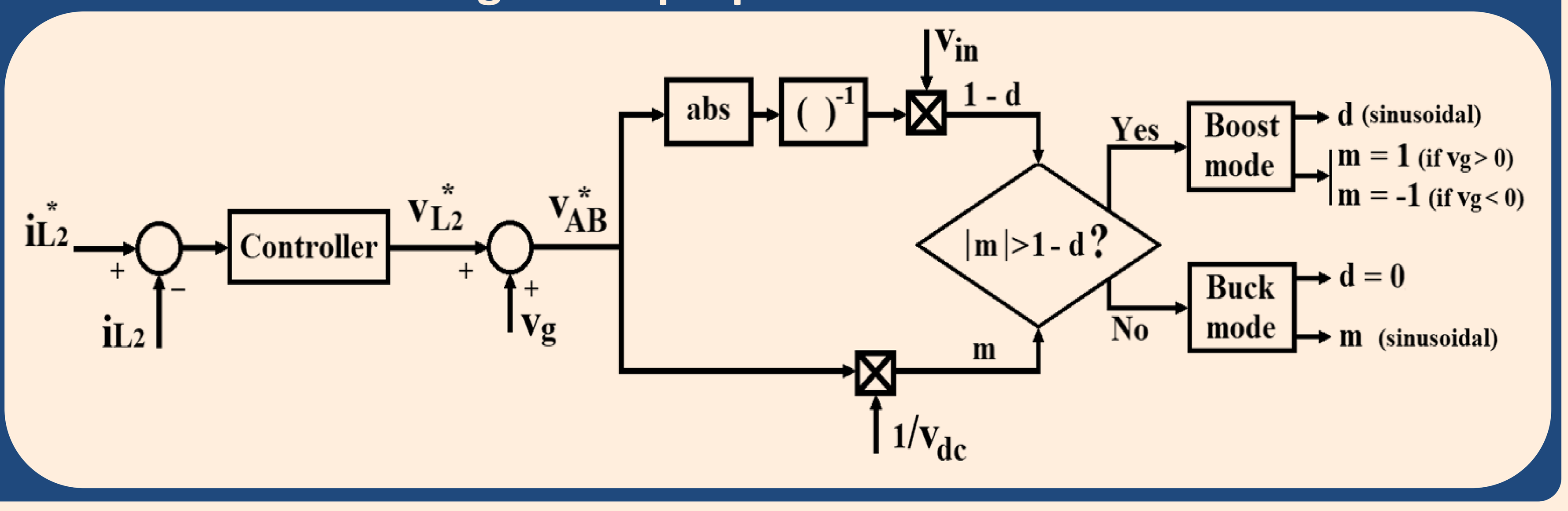
INTRODUCTION

- **Dual-mode control methods for two-stage inverters have been widely analysed because of their high efficiency.**
- **Their main weak point is the abrupt transition between modes, affecting grid current quality.**
- **By applying suitable feed-forward compensations, the paper proposes a dual-mode soft-transition control method with universal controller for current control loop.**

Conversion topology



Block Diagram of proposed dual-mode control



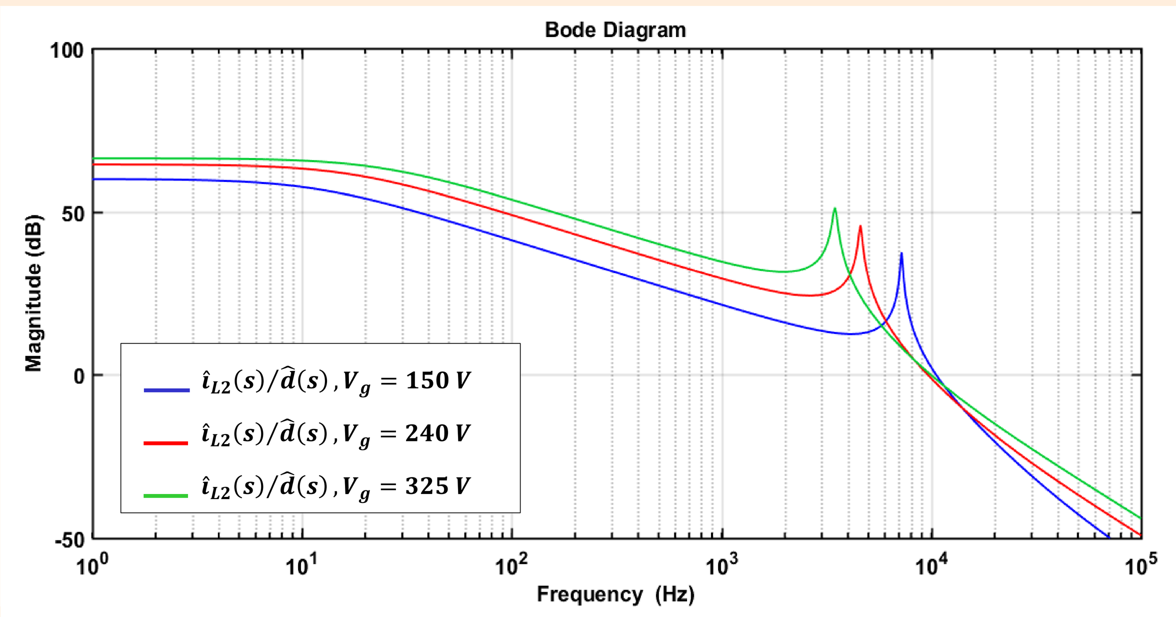
CURRENT CONTROL LOOP DESIGN

- Buck mode: $\frac{\hat{i}_{L2}(s)}{\hat{v}_{L2}(s)} = \frac{1}{L_2 \cdot s + R_2} \approx \frac{1}{L_2 \cdot s}$

In **Buck mode,** control-to-grid current plant is a **first-order minimum phase system.**

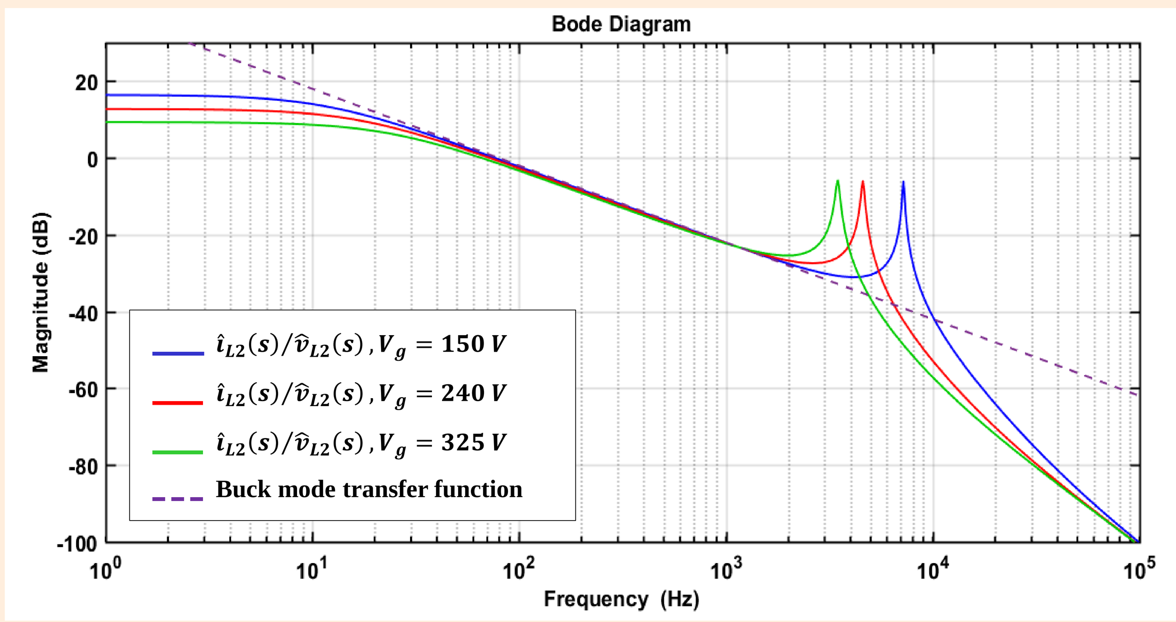
- Boost mode: $\frac{\hat{i}_{L2}(s)}{\hat{d}(s)} = \frac{-L_1 I_{L1} s - R_1 I_{L1} + V_{dc}(1-D)}{L_1 C_{dc} L_2 s^3 + (L_2 R_1 + L_1 R_2) C_{dc} s^2 + \left(C_{dc} R_1 R_2 + L_2 (1-D)^2 + L_1\right) s + R_1 + R_2 (1-D)^2}$

In **Boost mode, control-to-grid current plant is a third-order system** with both resonance and magnitude operating-point dependent.



Peak resonance and variable magnitude affect control feasibility.

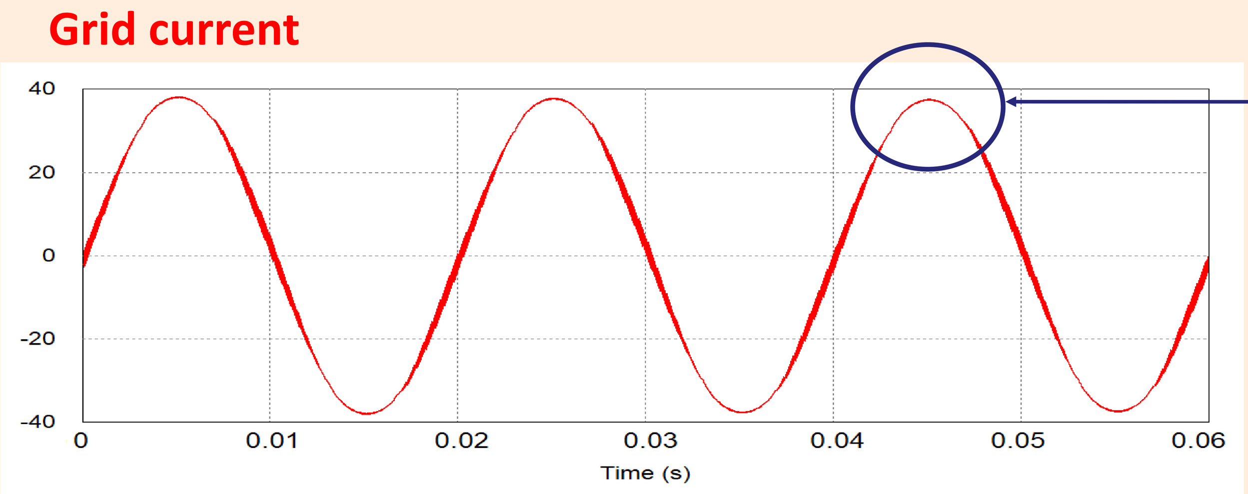
Applying proposed feed-forward compensations



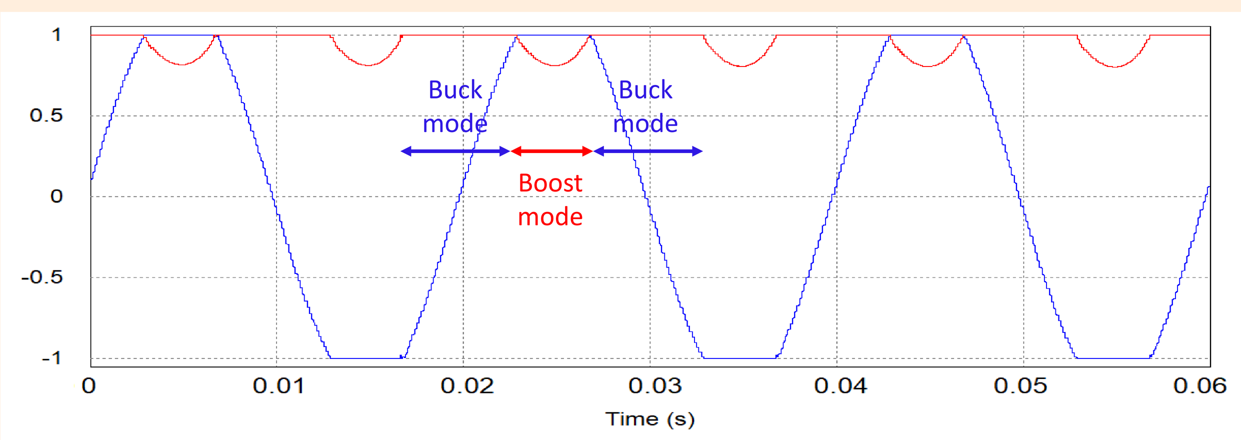
$$\frac{\hat{i}_{L2}(s)}{\hat{v}_{L2}(s)} = \frac{-L_1 I_{L1}(1-D)s/V_{dc} - R_1 I_{L1}(1-D)/V_{dc} + (1-D)^2}{L_1 C_{dc} L_2 s^3 + (L_2 R_1 + L_1 R_2) C_{dc} s^2 + \left(C_{dc} R_1 R_2 + L_2 (1-D)^2 + L_1\right) s + R_1 + R_2 (1-D)^2} \approx \frac{1}{L_2 \cdot s}$$ in f_c range

SIMULATION RESULTS

Grid current



1 – d **m**



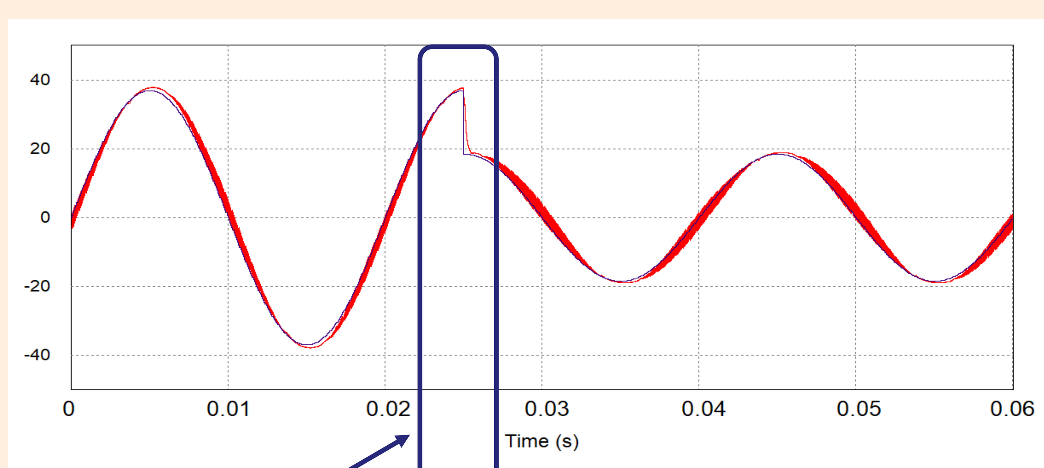
Soft-transition between Buck mode and Boost mode

PV generator at MPP

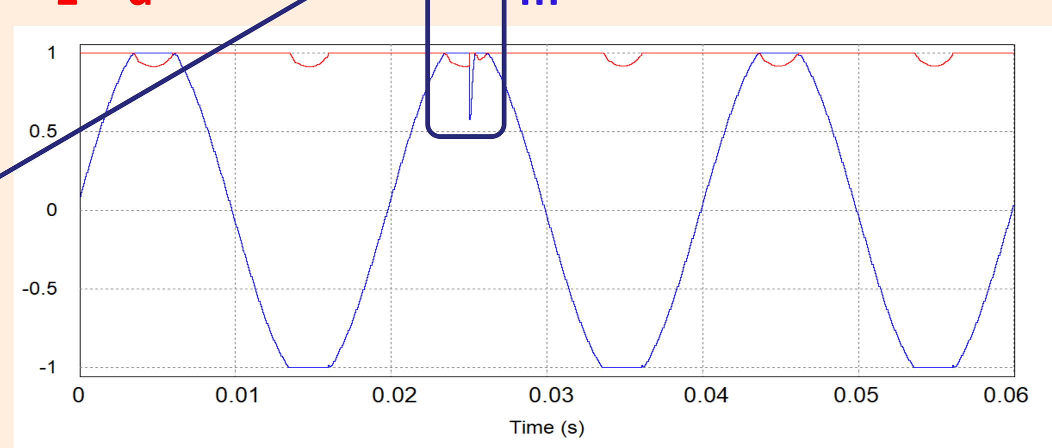
$v_{in} = 263\ V$

$THD = 2.82\%$

Grid current **Reference**



1 – d **m**



Current control loop **dynamic response**: step from nominal power output to 50% power output.

CONCLUSION

- **By applying the proposed feed-forward compensations only one controller is used for both operating modes.**
- **The proposed dual-mode control method achieves high-quality grid current and fast dynamic response, as shown by the simulation results.**

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