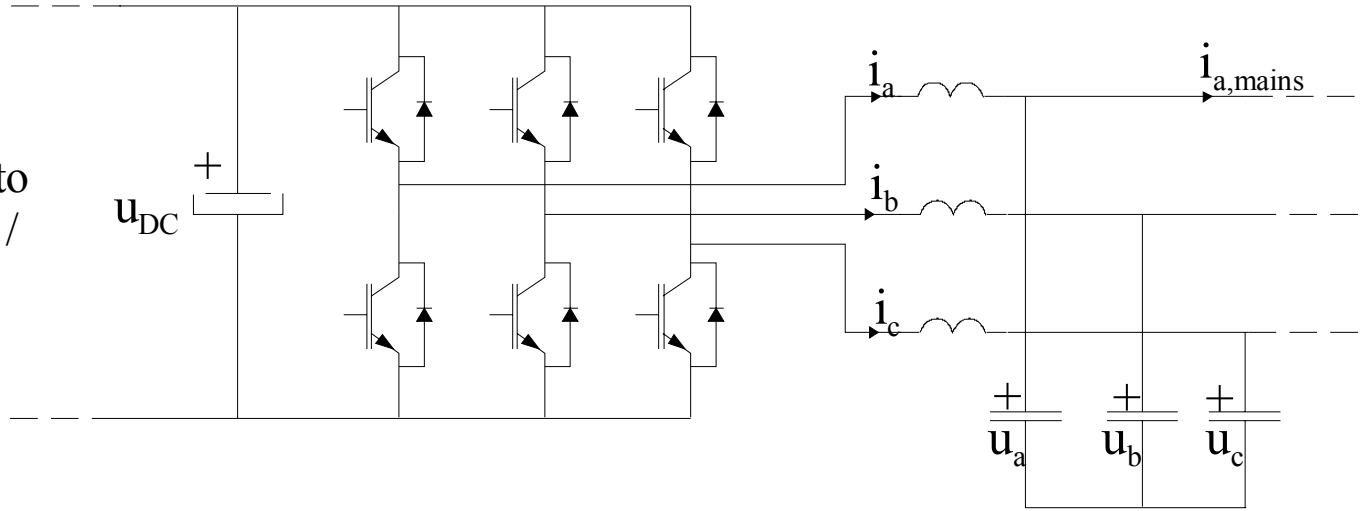
Project memo AN 02.12.56

Active front-end-converter, model verifications and design challenges

Objectives

- Verify simulation model against measurement on laboratory set-up.
- Summarize challenges related to active front-end converters that need further attention
- NOTE: The model is intended for investigation of phenomena in the frequency range from DC to well above switching frequency (not including radio frequency phenomena)

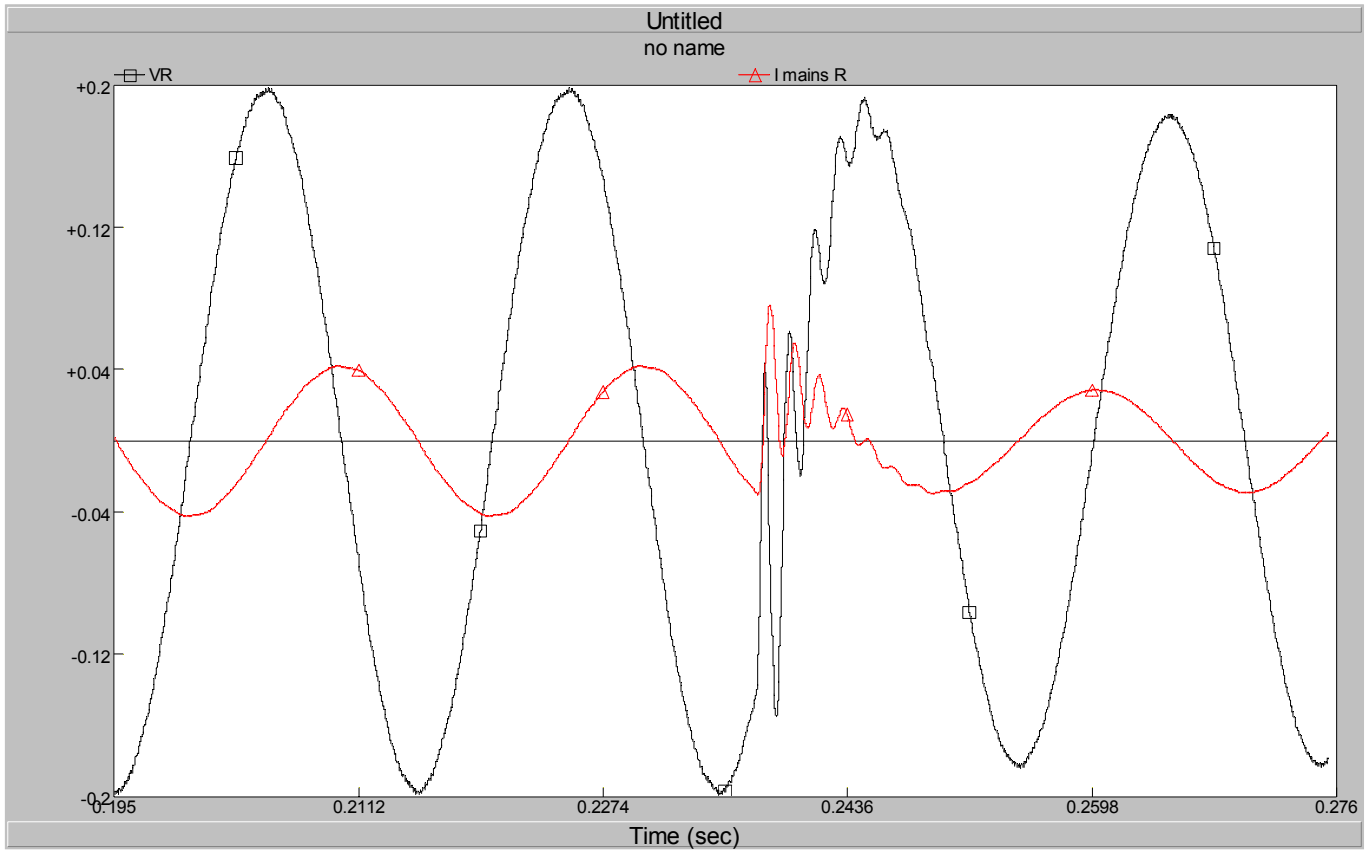
Principal drawing of power circuit



Case description

- DC-link voltage reference: 400 V
- AC-network line voltage: 230V rms
- Reactive current reference: Initially +35A peak and then stepped to –35A peak (momentarily reversal of reactive power flow from lag to lead)
- No other load or source connected to the DC-link. Only a small active current component is needed to cover the power losses in the converter.

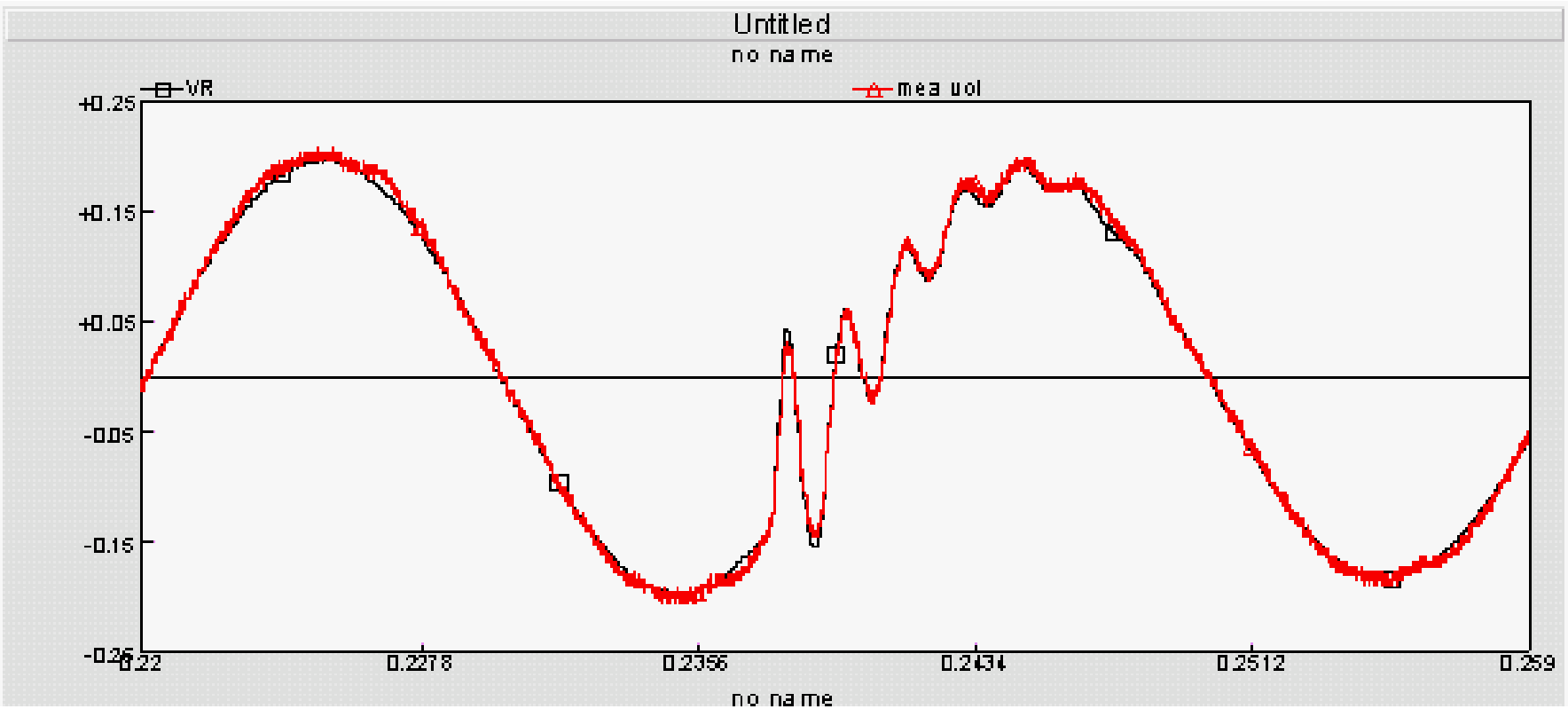
Illustration of the verification case



Filter capacitor voltage

AC grid current

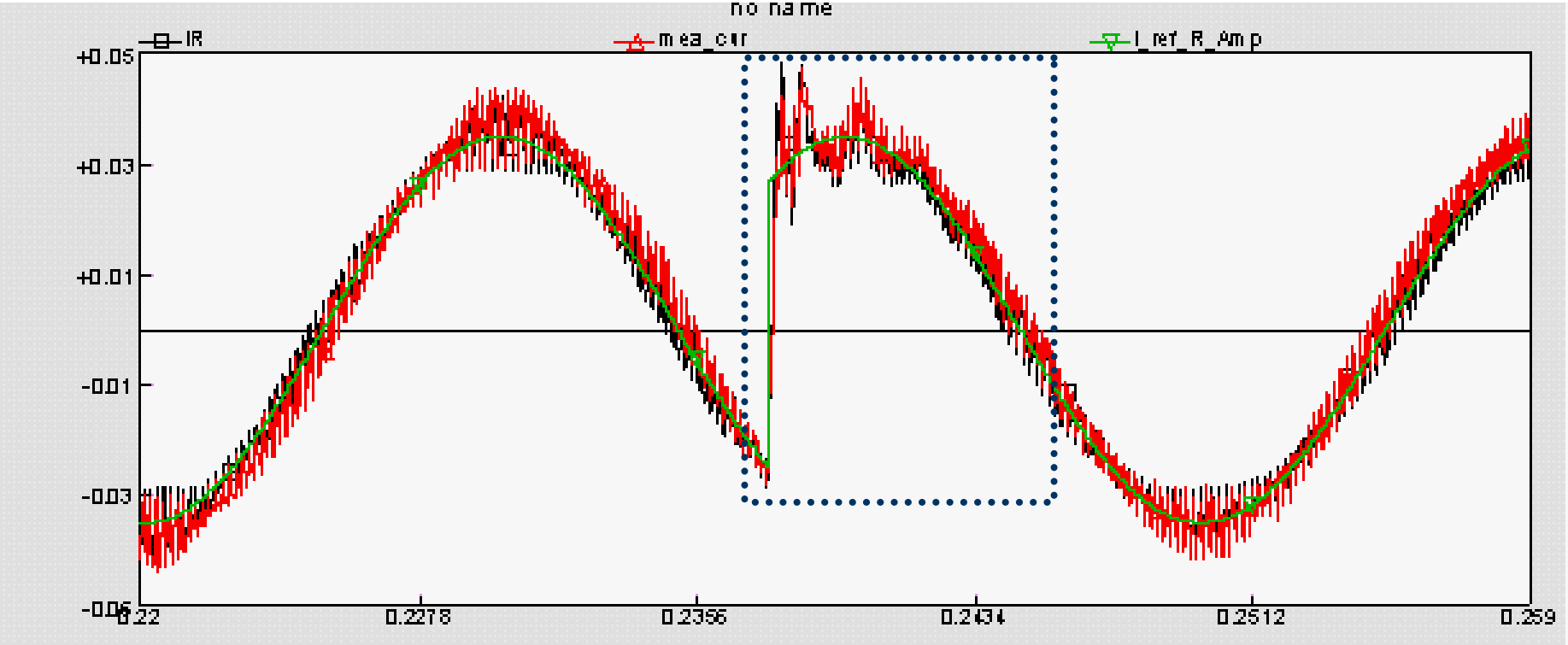
Capacitor voltage



Simulated

Measured

Converter current and current reference

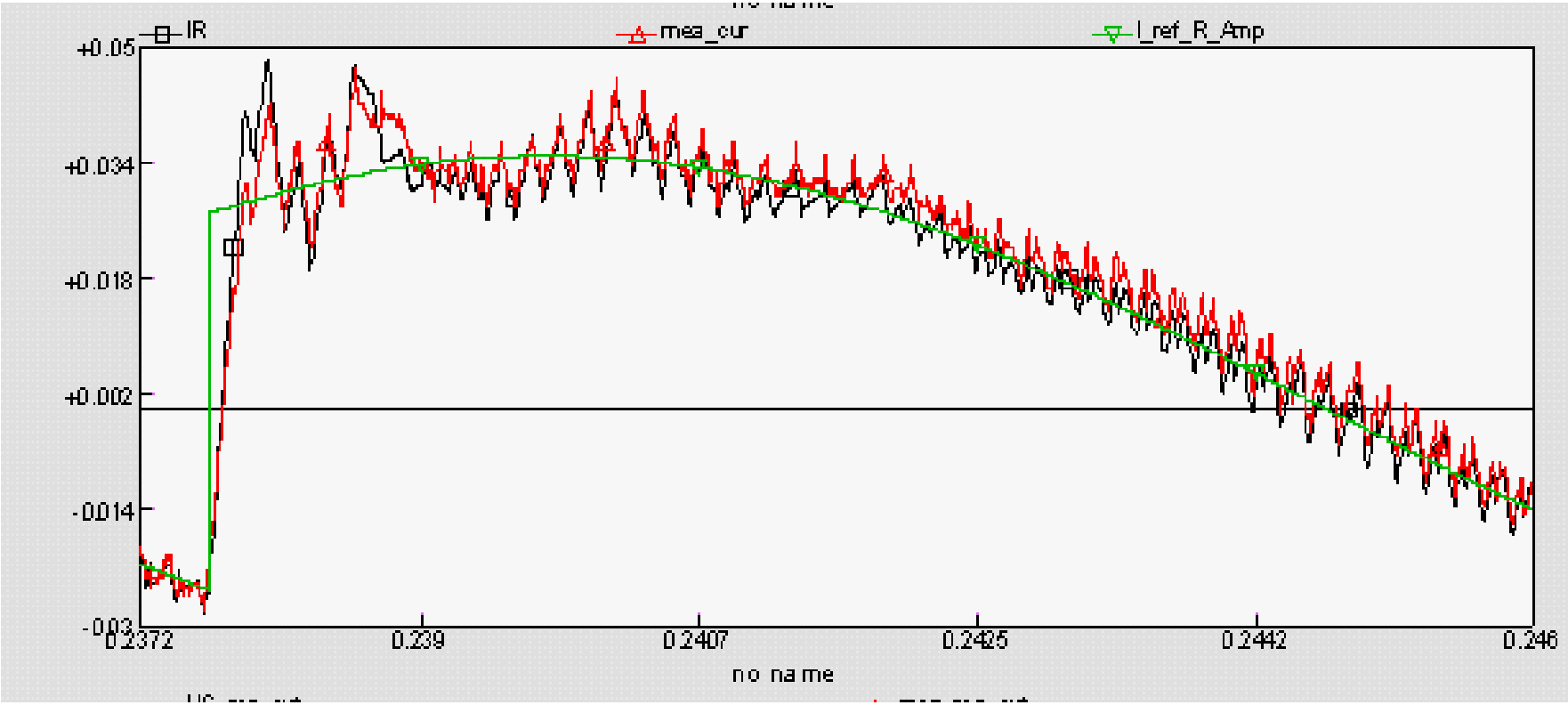


Simulated

Measured

Simulated refernce

Zoom of previous slide



Simulated

Measured

Simulated refernce

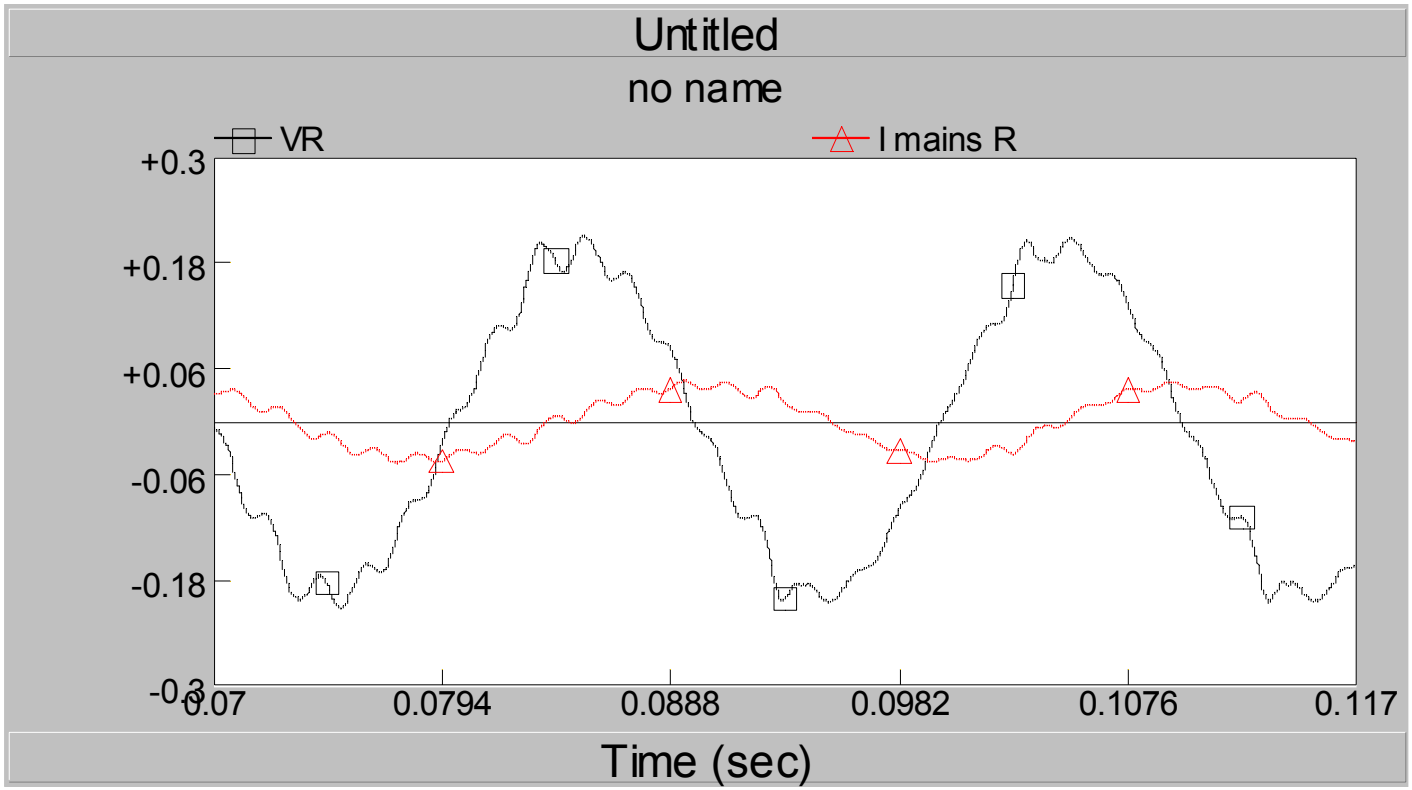
Conclusions model verification

- Good agreement between simulated and measured quantities
- The converter model is sufficient accurate for its intended use for future investigation and improvement of active front-end converters
- NOTE: Intended use is the frequency range from DC quantities up to well above switching frequency (not the radio frequency range)

Challenges that need further attention

- Oscillations between supply network inductance and AC-side filter capacitor.
- Consequences of AC-side filter capacitor working as a filter for other components connected to the AC-side network (typically diode rectifiers).
- Design of AC-side filter.
- Common mode interference (to AC-network)
- Possible dangerous constant power load behaviour.
- Converter response to transients and failures in AC-network
- Active damping of filter oscillations
- Optimal use of measurements

Illustration of challenges



Simulated filter capacitor voltage (kV / black / squares) and AC-network current (kA, red /triangles). A single-phase peak diode rectifier injects harmonics that flows into the AC-filter of the active front-end converter

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PROJECT MEMO

MEMO CONCERNS

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A simulation model of the active front-end converter prototype has been established and has been documented in [1]. Simulated behaviour has now been compared to measurements taken on the laboratory prototype. These comparisons are presented in this memo as a verification of the simulation model.

The agreement between simulated and measured quantities is considered to be good. Proposals for further model refinement are included, although the model is already sufficient for its intended use in future investigation and improvement of active front-end converters. This includes effect in the frequency range from DC quantities up to well above switching frequency. The model is however not developed and suited for analysis of phenomena in the radio frequency range.

This memo also outlines challenges that need further attention:

- Oscillations between supply network inductance and AC-side filter capacitor.
- Consequences of AC-side filter capacitor working as a filter for other components connected to the AC-side network (typically diode rectifiers).
- Design of AC-side filter.
- Common mode interference (to AC-network)
- Possible problematic constant power load behaviour.
- Converter response to transients and failures in AC-network
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