Project memo AN 01.12.97

Updated simulation model of active front end converter

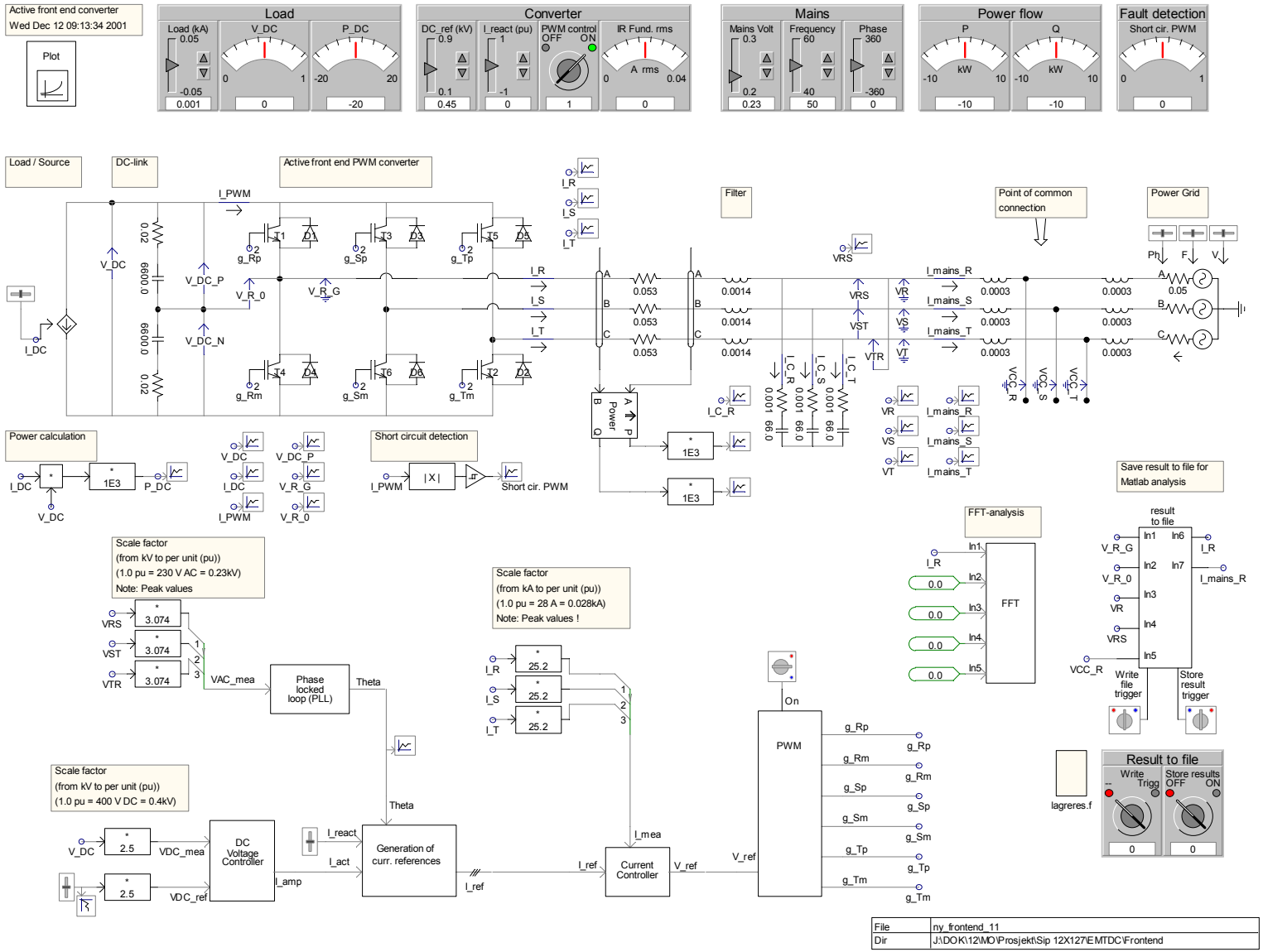
Objectives

- Implement a complete dynamic model of an active front-end converter (grid connected voltage source PWM converter)
- The model is to be implemented in the simulation software PSCAD/EMTDC
- Illustrate how Mathcad can be used for stability analysis of converter controller
- Illustarte how Matlab can be used for harmonic analysis

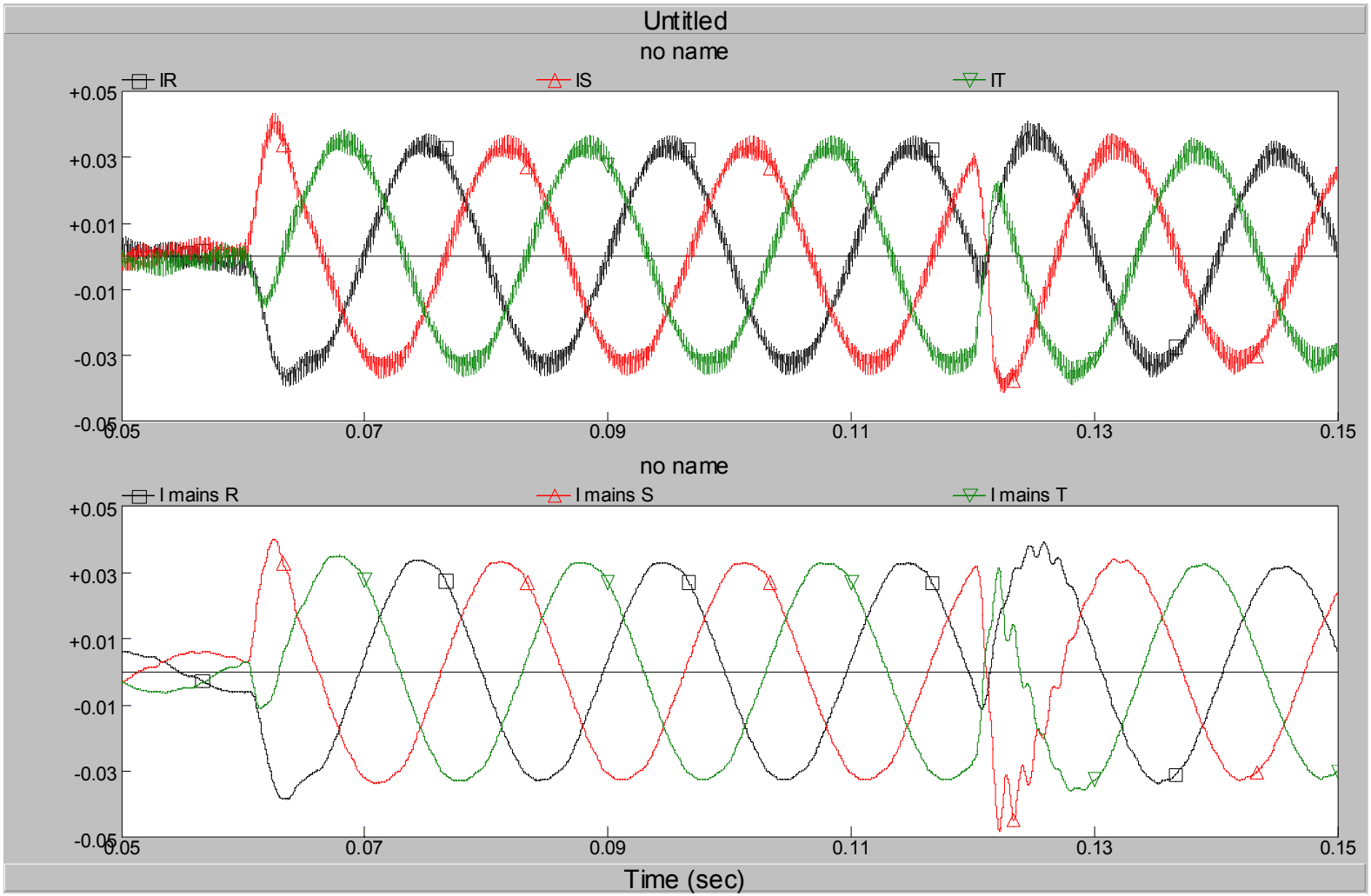
Active front-end characteristics

- Active and reactive power flow can be controlled in both directions and independently.
- Possibility for sinusoidal current drawn from, or delivered to, the power grid
- Small filter requirements compared to traditional thyristor converters
- The DC-link voltage level can be controlled
- Can be used as the only power source in an AC network (stand-alone application)
- Can inject currents to compensate for non-linear loads or for transients (e.g. operating as an active filter)
- Very short response time (step changes in active / reactive power and current in less than a ms)

Simulation model (top level)



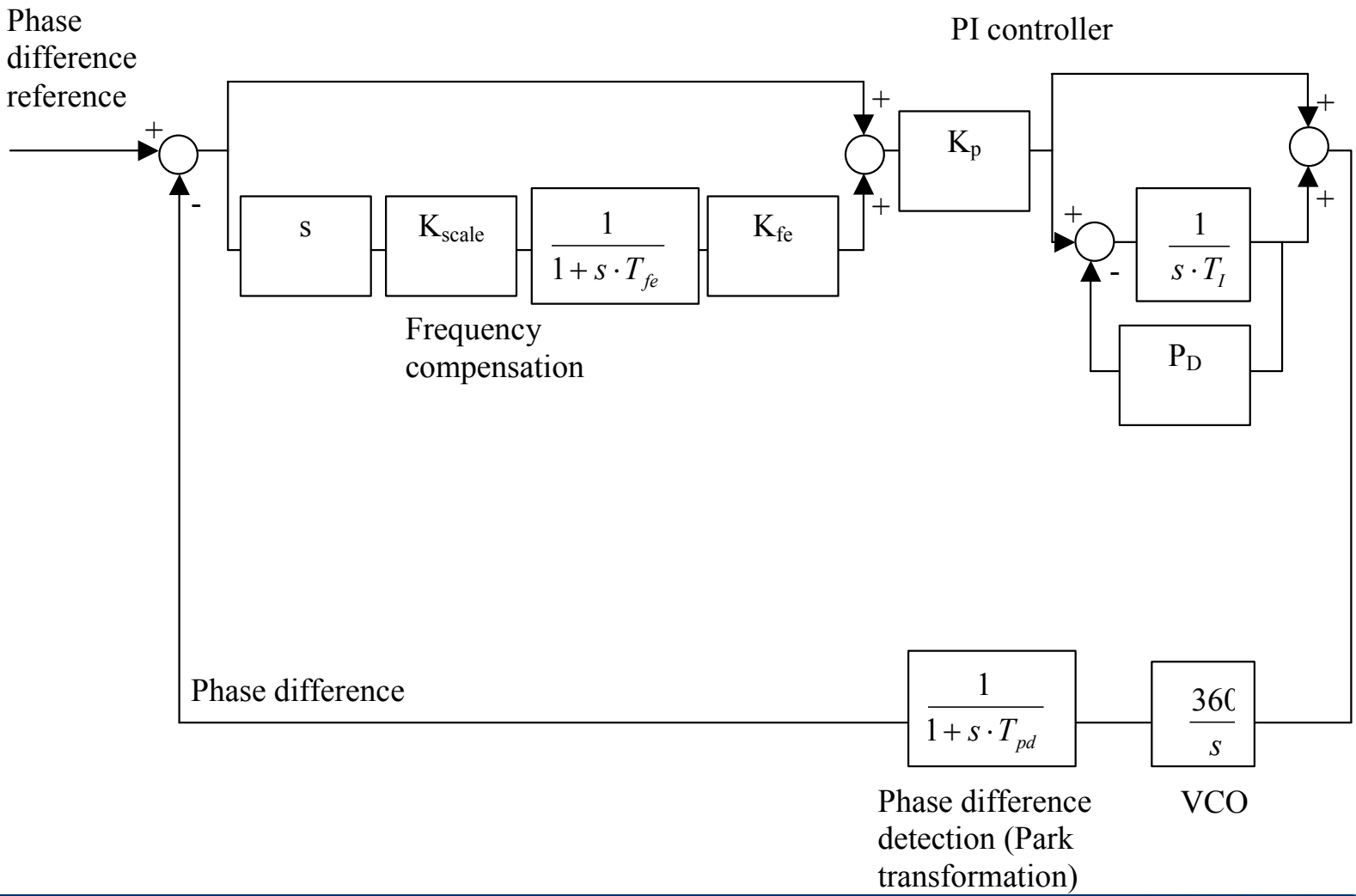
Example: Step reversal of reactive current/power flow



Convert. currents before filtering

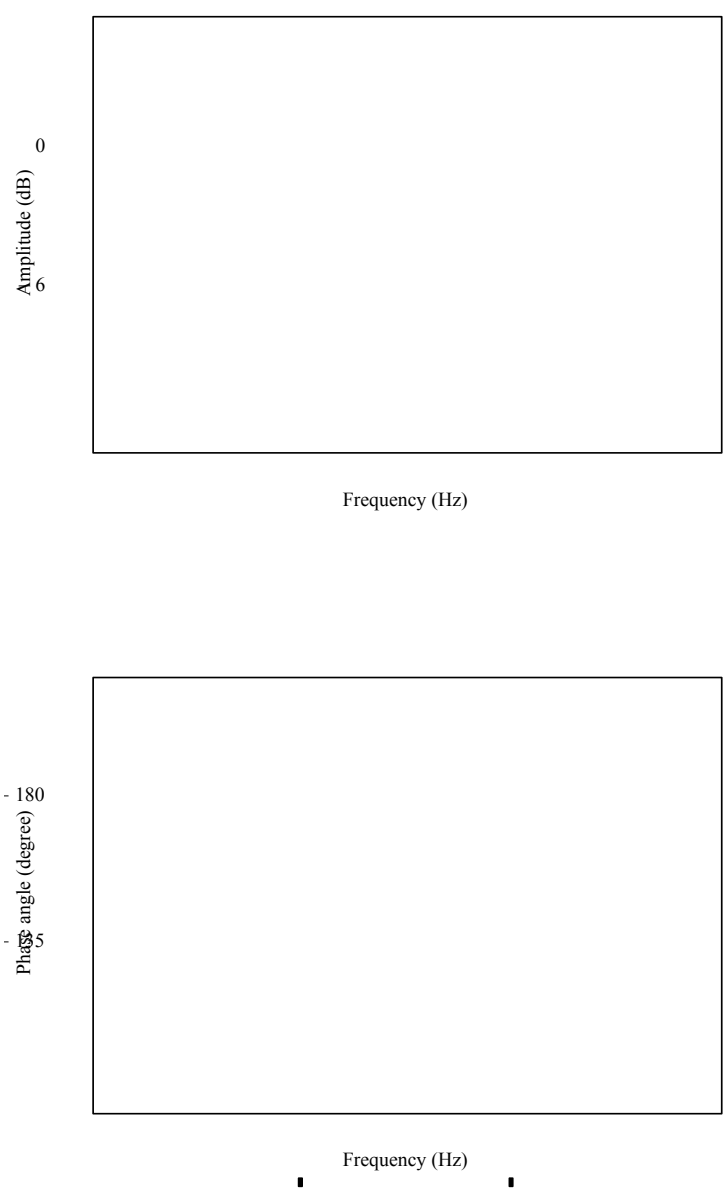
Convert. currents after filtering

Stability analysis: Phase locked loop

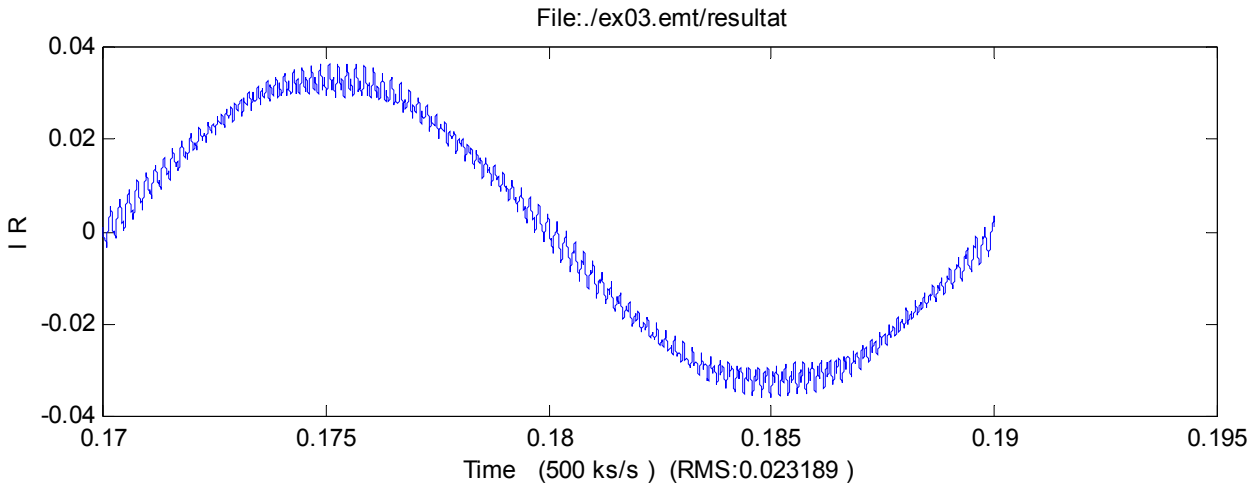


Stability analysis of the phase locked loop

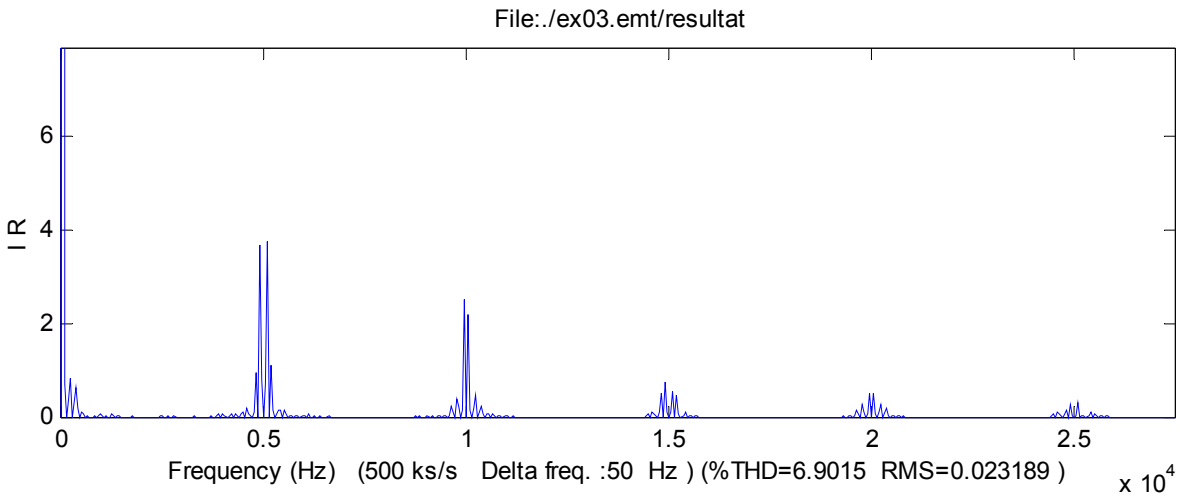
(Mathcad)



Example: Harmonic content in converter current (Matlab)



Current in filter inductor



Harmonics in % of fundamental

x 10^4 Hz on x-axis

Conclusions

- SINTEF Energy Research now have models and analysis tools well suited for design and verification of active front-end converters.
- The established model and the analysis tools (PSCAD/EMTDC) are well suited for further investigation on problems related to interfacing of alternative energy sources and energy storage devices to the power grid or to an autonomous power system.

SINTEF Energy Research

SINTEF Energy Research

Address: NO-7465 Trondheim, NORWAY
Reception: Sem Sælands vei 11
Telephone: +47 73 59 72 00
Telefax: +47 73 59 72 50

http://www.energy.sintef.no

Enterprise No.:
NO 939 350 675 MVA

PROJECT MEMO

MEMO CONCERNS

Updated simulation model of active front end converter

DISTRIBUTION
Magnar Hernes (SEfAS)
Kjell Ljøkelsøy (SEfAS)
Nils Arild Ringheim (SEfAS)
Olve Mo (SEfAS)

AN NO.	CLASSIFICATION	REVIEWED BY
AN011297	Unrestricted	Magnar Hernes

ELECTRONIC FILE CODE	AUTHOR(S)	DATE
011123Mo145023	Olve Mo	2001-11-23
PROJECT NO.		NO. OF PAGES
12X127	Olve.Mo@energy.sintef.no	64

DIVISION	LOCATION	LOCAL FAX
Energy Systems	Sem Sælands Vei 11	+47 73597250

SUMMARY

This memo is a continuation and systematisation of previous work on mains integrated converters. It is a part of the result of the Strategic Institute Programme (SIP) “Power electronics and energy storage technologies for cost- and energy efficient power systems” funded by The Research Council of Norway.

A complete dynamic model of an active front-end converter is presented in this memo. The model is implemented in the PSCAD/EMTDC simulation software and includes both the power circuit and the control loops.

The memo also shows how MatLab can be used for calculation of harmonics and how MatCad can be used for investigation of converter stability analysis and also for determination of possible AC-filter resonance frequencies. The simulation examples clearly show that the filter design is a very important part of an active front-end converter.

The memo shows that SINTEF Energy Research now have models and analysis tools well suited for design and verification of active front-end converters. The established model and the analysis tools are also well suited for further investigation on problems related to interfacing of alternative energy sources and energy storage devices to the power grid or to an autonomous power system.

Further work will be:

- Define and describe design criteria for the controllers of the active front-end converter in different power system applications.
- Thorough investigation of AC-filter design for active front-end converters.

TABLE OF CONTENTS

Page