A) General Information

Acronym:	**SPVSYS**
Title of the User-Project:	**Smart Photovoltaic Systems**
TA Call:	**Call 5**
Host Research Infrastructure:	**Fraunhofer IWES**
Starting Date:	**15.10.2012**
End Date:	**26.10.2012**
Lead User :	**Prof Remus Teodorescu**
Organization:	**Aalborg University, Denmark, www.et.aau.dk**
Additional Users:	**Bogdan Craciun, PhD**

B) Summary of the User-Project

Photovoltaic (PV) power among all renewable energies had the most accelerated growth rate in terms of installed capacity in recent years. Transmission System Operators (TSOs) changed their perspective about PV power and started to include it into their planning and operation, imposing PV systems to be more active in grid support. Therefore, a better understanding and detailed analysis of the PV systems interaction with the grid is needed; hence power hardware in the loop (PHIL) testing involving PV power became an interesting subject to look into. To test PV systems for grid code (GC) compliance and supply of ancillary services, first the grid has to be simulated using PHIL, but in order to achieve it, different interface algorithms (IA) had to be evaluated in terms of system stability and signal accuracy.

C) Results

The necessity of having PV systems which can offer more than the produced active power is on the market and PV manufacturers began developing control strategies for ancillary services and grid support. In order to accomplish this, first of the entire system has to be simulated at the same power level as the PV system under test. The simulated grid must reproduce all the conditions that are present in a normal grid with an increased interest on transients. The investigation compares two different IAs and analyses them in terms of stability and signal accuracy for PHIL testing. Given the fact that DIM presents obvious advantages compared with ITM, the former was chosen to be applied for grid simulation and PV system testing.

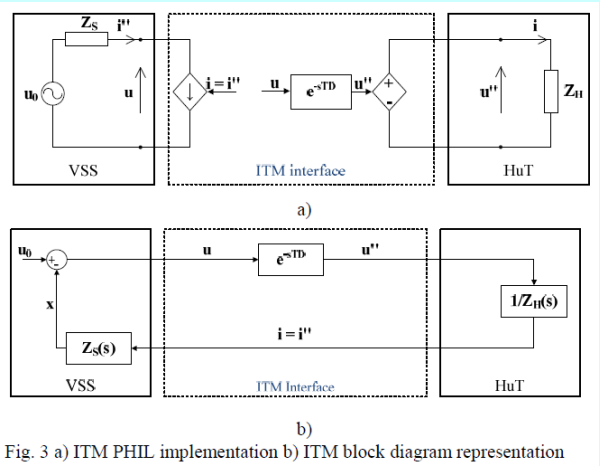

Fig. 3 a) ITM PHIL implementation b) ITM block diagram representation

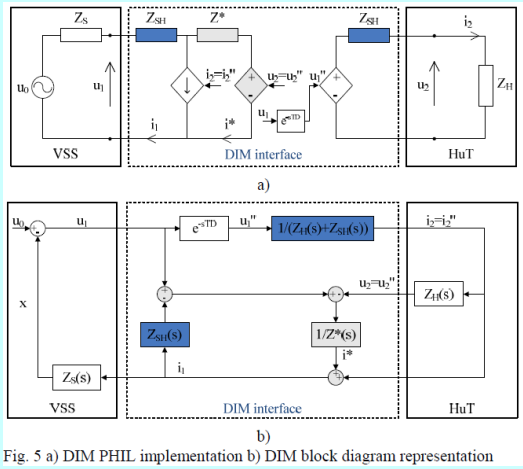

Fig. 5 a) DIM PHIL implementation b) DIM block diagram representation

To link the simulation environment with the HuT, IAs are used to guarantee a stable and accurate test facility. In this work ITM and DIM were tested and analyzed.

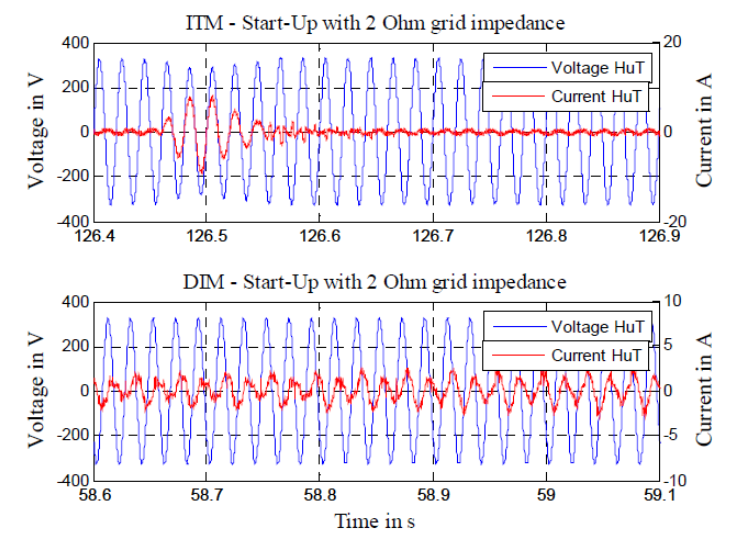

Fig. 10 Start-up of the PV system with a) ITM b) DIM

It can be concluded that DIM has several advantages compared with ITM since the method proved to have a stable and accurate performance under every test condition. PHIL, which emulates the behavior of a LV grid using DIM, was applied as a test bench to examine the behavior of a PV system which was the HuT. In this situation the emulated grid had to have the same behavior as a normal LV network and had to reproduce all types of instabilities present in the grid.

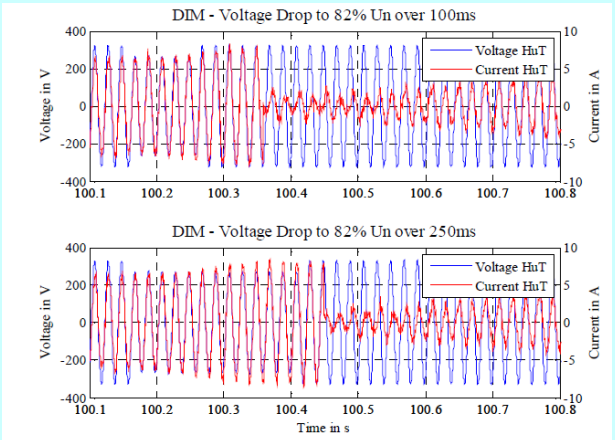

Fig. 11 Voltage dip PHIL testing results

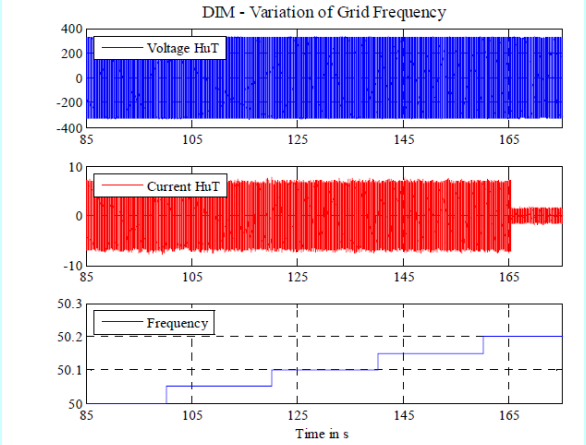

Fig. 12 Frequency deviation PHIL testing results (frequency increase)

Voltage and frequency support became a major concern for PV industry in the recent years and PHIL fills the gap and opens the possibility to test present and future control strategies of grid connected PV systems. Last but not least, PHIL testing can emulate even the cases defined in the newest GCs developed by the TSO's within ENTSO-E, where the main focus is on FRT support and FSM operation.

D) Dissemination of the Results

Paper submitted to IECON 2013, the 39th Annual Conference of the IEEE Industrial Electronics Society, November 10-13, 2013, Vienna, Austria.

E) Use of the Resources

Nr. of Users involved:	**1**
Access Days:	**10**
Stay Days:	**10**