P2-316 – Massive Parallel Current Power Amplifier Concept for Power Hardware in the Loop Applications

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Abstract:

The development of the smartgrid increases the complexity of the current electric grid. To verify and validate the operation of the systems involved in it, Power Hardware-In-the- Loop (PHIL) technique allows to test the complete system in an exhaustive way. But the reduced bandwidth of the overall test system can cause inaccuracies and instabilities, which can be harmful for the Hardware Under Test (HUT) or the people who are performing the test.

To improve the PHIL performance, this paper proposes a new concept of high bandwidth current amplifier. It is based on a topology of massive parallel interleaved buck-boost converter, which distribute in an equal manner the total current in all the branches. This current reduction allows to use transistors with better switching behaviour, which increase the bandwidth of the converter. Furthermore, a Discontinuous Conduction Mode (DCM) is used, obtaining the nominal output current in only one switching cycle. Description of the concept and the design parameters are provided. Finally, the behaviour of the proposed Power Amplifier (PA) at high frequency setpoint currents is shown in a Matlab/Simulink simulation.

Massive parallel current power amplifier	
Nominal power	20.8 kW
Nominal voltage	±325 V
Nominal current	±64 A
Switching frequency	144 kHz
Bandwidth	> 48 kHz
Number branches	16
Maximum average current per branch	±4 A
Maximum peak current per branch	15 A
Current Ripple	3% Inom
DC bus voltage	800 V
Inductance branch	50 µH

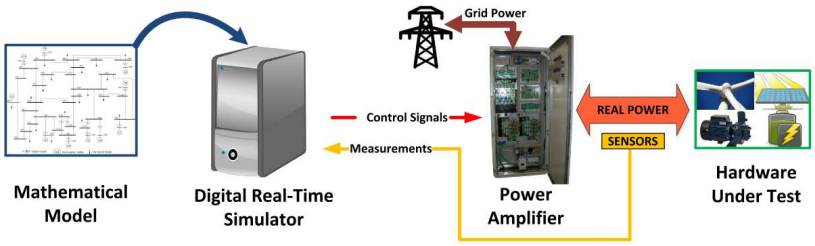

Figure 1 – PHIL basic structure, identifying most representative subsystems: Mathematical model, Digital Real-Time Simulator (DRTS), Power Amplifier (PA), and Hardware Under Test (HUT).

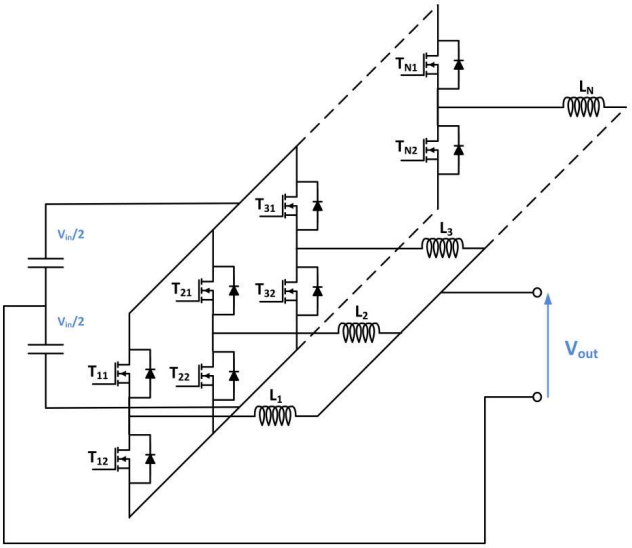

Figure 2 – Schematic of the proposed massive parallel current power amplifier.

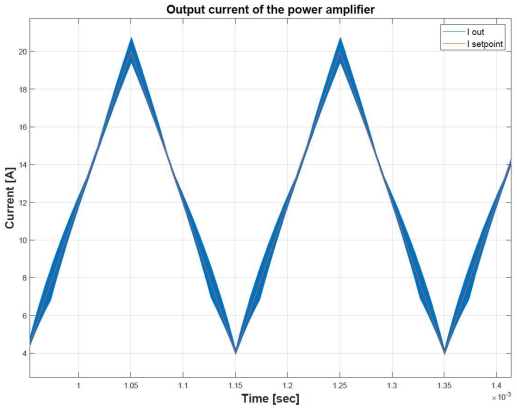

Figure 3 – Emulation of a triangular current switching behaviour of a converter which works at 5 kHz.

Conclusion:

In order to guarantee the stability of PHIL tests, the PA bandwidth plays a major role. This new concept of current PA makes it suitable for PHIL applications, due to the achieved bandwidth at high power operation. This current type high bandwidth amplifiers can be used to test voltage sources as transformers, grid forming converters or batteries.

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