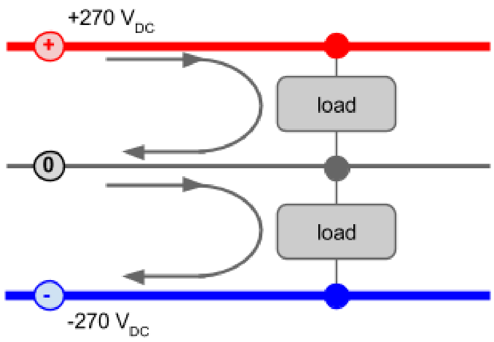
Smart Programmable Load and Source for more-electric aircraft testing

Tags: Energy Management, Automotive

State of the art – Background

Future aircraft grids intend to use high voltage DC buses to distribute electric power in the aircraft. These DC buses feed various loads such as electromechanical and electro hydraulic actuators. Currently, 270 V_{DC} and 540 V_{DC} are the voltage levels being considered for standardisation. The first generation of more electric aircrafts will run on 270 V_{DC} . 540 V_{DC} is a candidate for later generations of aircraft grids.

The figure below shows the example of a 270 V_{DC} bus. As shown, this high-voltage DC bus provides both -270 VDC and +270 VDC with respect to the aircraft chassis. Use of both a positive and negative voltage allows to maximize power transfer while minimizing the amount of copper needed to do so. Proper load balancing between the positive and negative line leads to a minimum of current passing through the 0 V return path. As such, copper needed to implement the 0 V return path can be minimized.



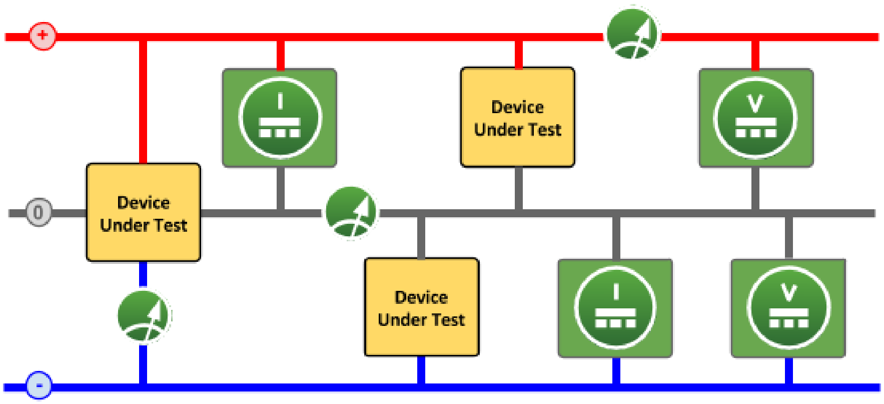
Aircraft grid voltages and currents

Power transfers between the aircraft grid and its connected components go in both directions. Some components will only consume power but other components, like batteries and motor/generators may both consume (store) and deliver power to the grid. Grid stability is determined by the power balance between components delivering power and components consuming power. In studying grid stability behaviour, both the long-term and short-term power balance is of importance. Short-term power imbalances may cause transients that can disturb the behaviour of the devices attached.

Objectives

Given the above, systems needed for the physical emulation and test of DC aircraft grids must satisfy following requirements

- Solutions must provide or interact with 0 V_{DC} , +270 (540) V_{DC} and -270 (-540) V_{DC} lines.
- For generator emulation, system outputs must be available that act as 270 (540) V_{DC} voltage sources capable to inject power into or absorb power from a load under test..
- For load emulation, system outputs must be available that act as current sources able to inject power in or absorb power from a 270 (540) V_{DC} generator under test.
- Both voltage source and current source outputs must be capable to inject or absorb fast-varying power transients.
- For grid and component monitoring, there is a need for distributed current and voltage measurements. Measurements need to be time-synchronized with each other and with the power actuators (generator/load emulations) as to provide a grid-wide picture of the impact that components have on one another.
- Solutions must be scalable. As the grid grows, it must be easy to add or remove loads and sources as well as measurement points.



Aircraft grid test setups mix “real” devices-under-test with electrical load and generator emulations

An example of an aircraft DC grid with physical and emulated components is depicted above. Here, the components marked by “I” represent electrical load emulations (current sources) while the components marked by “V” represent generator emulations (voltage sources). The grid may also contain “real” devices under test (DUT).

Description of work

SPLS focuses on the design of a versatile power module that can act both as source and generator. The stage covers both DC and 400 Hz AC applications. DC applications include battery emulation, fuel cell emulation and emulation of hydro-electric and electromechanical actuators. AC applications include 400 Hz grid and load emulation.

The power stage’s flexibility is twofold

- Flexible hardware architecture: the system’s output section is partially reconfigurable. As such, it can optimally adapt to the characteristcis of the device under test.
- Flexible software architecture: the system builds on an open and flexible software platform. Software is highly configurable. Moreover, the entire system can easily be reprogrammed and is capable of running a multitude of (user-developed) application programs.

Software flexibility is linked to the innovative networking and signal processing architectures experimented with as part of the SPLS project.

Expected results

SPLS will deliver a versatile 33 kW power load and source that can handle both AC and DC applications. The SPLS module will be integrated in a more-electric aircraft test bench which is currently prepared by Labinal Power (Safran). The test bench will be used by aerospace companies to experiment with various electrical loads and sources and to test aircraft grid control and monitoring strategies.

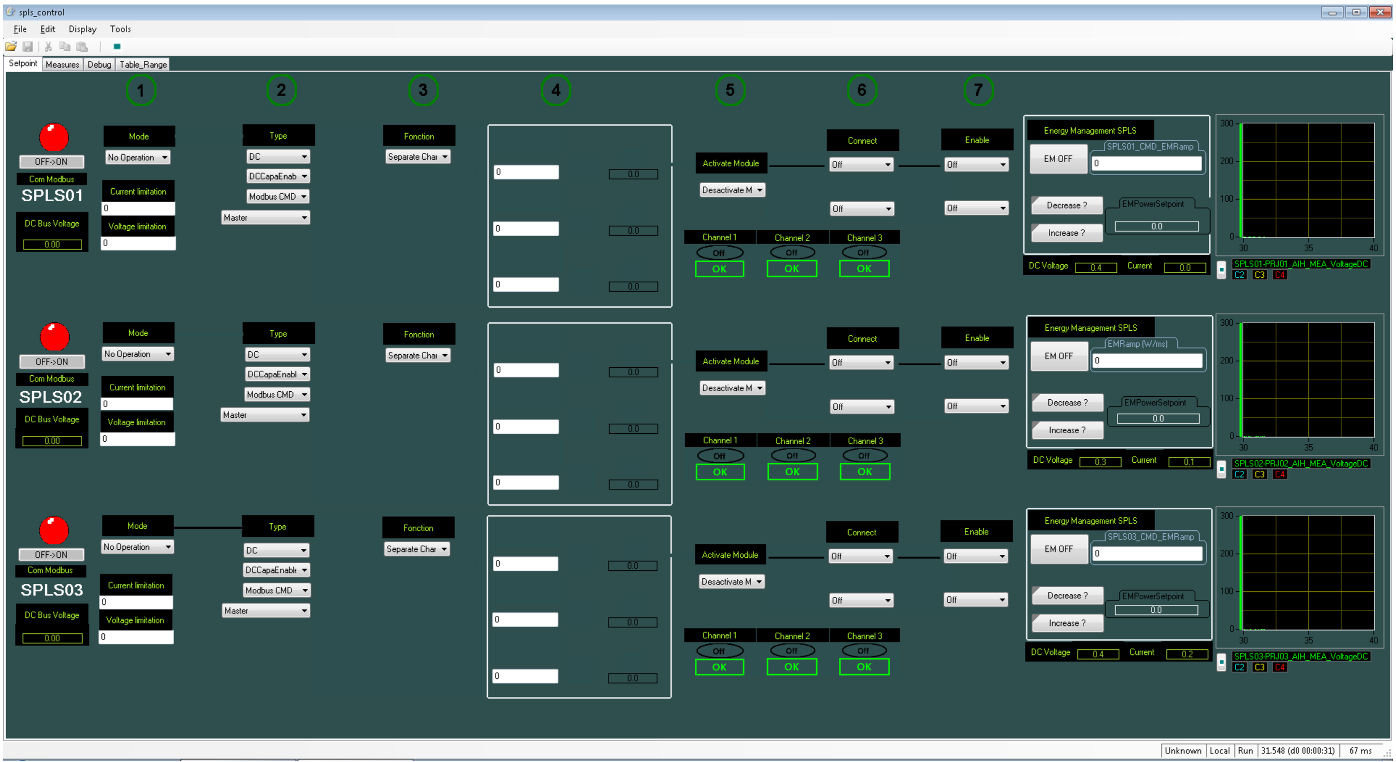
Environmental impact

The 3- wire DC bus architecture will result in a reduction of the amount of copper and thus weight compared with traditional 2-wire DC or AC busses.

This raw material and weight reduction contributes directly to the Clean Sky environmental objectives.

SPLS power flexible electrical load and source emulation power module.

The SPLS modules in place at the Clean Sky lab.



The GUI built to control the SPLS modules.

Project Summary

Acronym : **SPLS**

Name of proposal: **Smart Programmable Load and Source**

Technical domain: **Mechanical Actuators**

Involved ITD

Grant Agreement: **307727**

Instrument: **Clean Sky**

Total Cost: **€210,000.00**

Clean Sky contribution: **371**

Call: **SP1-JTI-CS-2011-03**

Starting date: **01/06/2012**

Ending date: **01/06/2016**

Duration: **48 months**

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