

> STATE OF THE ART – BACKGROUND

The development of the helicopters market is today limited because of their strong impact on environment: Their fuel consumption is high and produces a lot of emission; they generate a lot of noise both for the passengers (cabin noise) and for the people living close to the heliports (external noise). The main source of these inconvenient is due to the main rotor, especially its blades, which presently cannot dynamically adapt their aerodynamic profile to the desirable one. The consequence is a strong level of vibrations and noises from the rotor, such as Bladevortex interaction (BVI) noise, also called “blade slap”. This is especially in the cases of fast forward and descent flights. Other impacts of the inability of rotor blades to adapt their aerodynamic profiles to flight conditions are limited performance regarding flight envelope, speed and range.

To adapt the aerodynamic profiles of rotor blades, one solution is to add active flaps (trailing edge flaps, gurney flaps...). Such active flaps are actuated by piezo actuators, such as the Amplified Piezoelectric Actuators () from Cedrat Technologies. Because of the high requested bandwidth and their high capacitance, these piezo flaps require specific high power efficient electronic drivers.

> OBJECTIVES

The Eu FP7 Clean Sky PPSMPAB (Piezo Power Supply Module for Piezo Actuator Bench) project aimed at developing a Piezo Power Supply (PPS) offering the highest required power (9kVA) with a high efficiency, for driving piezo actuators, accounting for helicopter applications such as active flaps. Cedrat Technologies CTEC (coordinator, SME) and UJF-G2ELAB (partner, lab from Grenoble Joseph Fourier University) formed a consortium using their shared experience on piezoelectric actuators and high efficiency high power supplies to meet the GRC requested by the PPSMPAB project. The topic manager was Eurocopter.

The proposed development split the need in two main items:

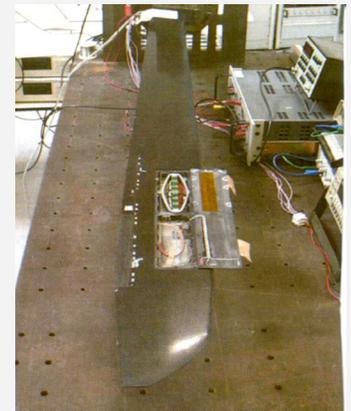
- The preferred direct current (DC)-DC converter providing the DC sources would be an isolated full bridge resonant converter, with adjustable bus DC voltage.
- The DC-AC 2-channels switching amplifier will provide the 2 x 4,5 kVA power with adjustable output voltage range (-200 / +1000V).

> DESCRIPTION OF WORKS

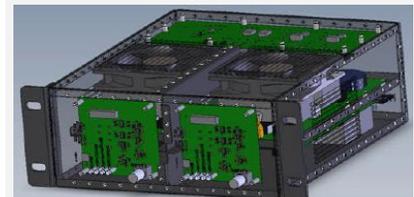
In this project, the starting point of the technology was in TRL1-2 (Technology Readiness Level), as there were some existing bases to work on, and some basic research were conducted to assess the feasibility of the technology. The objective identified in the project was to reach a TRL4 at the end of the project, which corresponded to a validation of the technology in laboratory conditions. The developed Piezo power supply (PPS) has involved both power electronics technology with Multi level structure, High frequency switching and Piezo technology.

The new features:

- Large power output
- Large output voltage
- Energy recovery with Bus capacitor storage
- Low consumption
- Embedded solution for aeronautics



Active flap of helicopter actuated by APA® (Collaboration between CTEC and Onera)



CAD Overview of the Piezo Power Supply (PPS) Module



Demonstrator of Piezo Power Supply (PPS)

> EXPECTED RESULTS

a) TIMELINE & MAIN MILESTONES

In the WP1 CTEC performed a technical, contractual and financial administration of the project and guaranteed the objectives and deadline complying.

In the WP2 relative to the Design concept & architecture, UJF-G2ELAB analysed electronic architectures (several being identified in the proposal) and technologies (MOSFET vs IGBT) and presented the results in form of trade-off, allowing the GRC Consortium to select the one to develop. Mock up were developed to establish the main characteristics.

In the WP3 concerning the Detailed design & manufacturing, CTEC performed the PPSM detailed design. One PPS prototype was manufactured and tested.

b) MATURITY OF WORKS PERFORMED

Successively, the works were performed to:

-Analyse the detailed specification of the actuation system and to elaborate a design concept and the architecture of the PPS in association with several preliminary designs. In this phase, the order of priority for the PPSM study was:

- weight and volume reduction
- cost (manufacturing and maintenance)
- efficiency

Based on the state of the art issued from the past works and the background of UJF-G2ELAB and CTEC in the field of power electronic and piezoelectricity, the most promising technologies were investigated in the field of the power amplifier for piezoelectric actuators. These works were composed of an analysis of the technical specifications to focus the work on the key points. From the works on the design concept, a preliminary performance evaluation of the PPSM was performed. Basic demonstrators were made by G2ELAB to back up the results of the preliminary performance evaluation.

- Perform the detailed design of the PPS starting from the detailed specification selected with the Cleansky GRC consortium and with the works provided from the previous tasks. First engineering iteration was performed to validate the core functions and auxiliary functions. Breadboards of the core of the DC/DC converter and the core of the amplifier were done by G2ELAB. CTEC manufactured the breadboards that interface with those two cores to obtain the first complete breadboard (non deliverable).

Modelling tasks of the electronics were performed. Those models were used to simulate and verify the expected functionality of the main functions of the PPS module. Only the core functions was modelled and simulated, the rest of the functions was verified by design, but not modelled nor simulated. This means that presently there is no complete electronic model of the PPS module available.

Finally a demonstrator of the PPS was issued to validate the power cores and a prototype was manufactured to test the electrical functionalities.

In terms of exploitable results at this stage, the know how in high power Switching Amplifier developed in PPSMPAB project has been beneficial for simpler Switching Amplifiers for piezoelectric actuators from Cedrat Technologies: Its SA75D is the highest power electronic for piezo available on the market. It generates up to 30A in the -20 +150V range, so 2.5kVA. It is simpler than the PPS because it is one level topology, but as the PPS it offers energy recovery. Dedicated oem versions for air & space applications in development will exploit even more the PPSMPAB results. This will allow for example to cover needs not only on active flaps but also in synthetic jets and pulsed jets.



Acronym :	PPSMPAB
Name of proposal:	Piezo Power Supply Module for Piezo Actuator Bench
Technical domain:	Mechanical Actuators
Involved ITD	Green Rotorcraft Innovative blade devices
Grant Agreement:	271872
Instrument:	Clean Sky
Total Cost:	427 350 €
Clean Sky contribution:	320 512.50 €
Call:	JTI-CS-2010-03
Starting date:	01.05.2011
Ending date:	30 avril 2014
Duration:	36 months
Coordinator contact details:	Dr Frank CLAEYSSSEN CEDRAT TECHNOLOGIES 59, chemin du Vieux Chêne 38246, Meylan Cedex France +33/4 56 58 04 00 frank.claeyssen@cedrat-tec.com
Project Officer:	Sébastien Dubois sebastien.dubois@cleansky.eu
Participating members	G2ELab – Université Joseph FOURRIER FR

For more information, please contact:

CEDRAT TECHNOLOGIES
59 Chemin du Vieux Chêne - Inovallée
38246 Meylan Cedex - France
actuator@cedrat-tec.com
Phone: +33 (0)4 56 58 04 00 - Fax: +33 (0)4 56 58 04 01