SSPC based Electrical Power Distribution Unit for a Part 23 aircraft

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Auteurs: Carlo Cardu, Saverio Birocchi
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Abstract

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Sponsors
SSPC based Electrical Power Distribution Unit for a Part 23 aircraft Carlo Cardu (1), Saverio Birocchi (2) 1: Electrical, Avionics & S/W Airworthiness Coordinator Piaggio Aero Industries (PAI) – Villanova d’Albenga (SV) – Italy ccardu@piaggioaero.it 2: HW/FW Design & Development Manager Blu Electronic – Desio (MB) – Italy saverio.birocchi@bluelectric.it

Abstract The P180 Avanti EVO is the latest version of the Piaggio Aero Industries “high end Part 23” Bi-Turboprop Model, where several systems have been renovated for achieving better performance. The MJB (Main Junction Box, alias the A/C Main Electrical Power Distribution Unit) is among the renovated equipment, including inside replacement of the previous power contactors with latest generation, lighter and compact ones, and most of all replacement of a large number of conventional CB and RCCB (Remote Control CB) with new generation SSPC (Solid State Power Controllers). In the following the architecture of the unit is presented along with zone changes considering the FFF (Form, Fit and Function) initial requirement to allow retrofit on older airframes, increasing electrical system performance.

MJB Description

The MJB is in charge to manage DC distribution, both primary (from power generation sources to aircraft busses) and secondary (from aircraft busses to aircraft loads), and perform protection functionalities. The former design was based on Remote Control Circuit Breakers (RCCB), Circuit Breakers (CB), Overload Sensors and Relays (power and signal). The new design has maintained the primary distribution through traditional CB’s, RCCB’s, overload sensors and mechanical power contactors, whilst the secondary distribution employs the new Solid State Power Controllers (SSPC) which inclusion has led to significant improvements as hereafter described.

Figure 1-New MJB (42x42x13 [cm])- 16 kg

Benefits

The design with SSPC has provided several advantages, such as: weight reduction, reliability improvement, system self-diagnostic functions, status and maintenance information to the ground crew (maintenance data of up to 80 flight hours is stored in the MJB and available to maintenance engineers). SSPC & Control Module An SSPC is a set of active devices (e.g. Micro controllers and MOSFETs) constituting the SSPC basic block for this design, providing a last generation power switch which can be programmed to ensure the desired protection function (e.g., traditional thermal protection). The device needs power to operate. The status of the device is continuously monitored through a data bus. A specific SW is required to manage
SSPC proper operation (activation thresholds, performance monitoring, data acquisition). The new SSPC’s are employed to provide secondary DC power distribution. They have been designed to maintain – as a minimum – all the functionalities, electrical interfaces and environmental performances of the traditional CB/RCCB, improving the performance. The SSPC’s and Control Module (CM) provide extensive test capabilities to allow system fault detection and status monitoring. On-ground the system allows the user to control each output and check each load providing a very quick analysis of the status of the different loads. During flight the SSPC’s continuously check load status and internal parameters throughout CBIT (voltage drop of the switch, current flowing, temperature,...) and act in case of anomalies. In addition the MJB CM (one CM can handle up to 60 SSPC channels) can transmit and collect data from every SSPC storing the data in a non-volatile memory to allow further analysis. The inclusion of the SSPC in the MJB has requested a mechanical redesign of the internal layout of the equipment that has been possible thanks to the modularity of the developed SSPC architecture and the high level of integration of the functions; to be noticed that integration is possible thanks to the very low power dissipation of the SSPC’s (typically less than 5W for a 100A size). SSPC are very efficient devices respect to the CB/RCCB: the series resistance that senses the current (the main contributor to power dissipation) is much lower than CB/RCCB reducing the generated heat (even 25% below the value of a CB/RCCB). In addition the SSPC mechanical arrangement has been studied to control the temperature rise (less than 30°C at full rated power) without significant mass overhead: comparing four traditional 10A RCCB’s with a 4 channel SSPC (capable of 25A for each channel) it is found that the weight of a 4 channel SSPC is five times less the RCCB’s weight. Safety and reliability analysis results show that the SSPC has a better MTBF than the traditional CB when considering the portion of the SSPC performing the same function of an old CB. Figure 2 – SSPC The developed SSPC are very modular, their outputs can be easily paralleled to reach even 100A channel rating. The output configuration and the tripping values can be configured, this means that trip current can be set or modified without any hardware change. SSPC SW allows flexibility and configurability. It performs functions as I2 t, continuous check, data storage, diagnostic information, ARINC429 communication in a very accurate way. As an example: traditional CB/RCCB have a trip threshold depending on the temperature, the SSPC intervention can be temperature independent reducing any drift to negligible value. Software (SW) certification has been achieved through RTCA DO-178B. No CEH has been used. During equipment qualification test it has been demonstrated that the developed SSPC is compliant to DO-160E Power input category Z and lightning induced transient susceptibility category A3G33. Certification Issues The design with SSPC has provided several operational and functional advantages, but at the same time caused the need to overcome issues and challenges normally not to be considered in a conventional pure electro-mechanical design. All of them were subjected to dedicated analysis and discussion during the certification process, leading to issuance of a CRI (Certification Review Item) to identify and agree between EASA and PAI all the issues and relevant solution. The CRI, with a supporting technical description note, was also used to verify the need for standardization activities at Certification Agency level. In the following, a list of the main topics raised during the certification process is provided. There are not agreed published documents concerning SSPC (TSO, CRIs, or aeronautical specifications such as SAE or MIL specs). A specific qualification process for the SSPC had to be defined that is different to what is done on conventional CB. With the new MJB, conventional CB/RCCB are not simply replaced by SSPC, keeping their independence: new MJB is characterized by a high level of integration, with several functions performed by few items, and the need of more items to perform a single function. Use of common technology, as also common supply of power or data for several SSPC, had to be considered. As a consequence, a new common mode failure was identified (all “circuit breakers” stuck open), not envisaged with the previous design, requiring a deeper safety analysis to define partitioned DAL’s within the equipment and, consequently, the Class of embedded S/W. Due to the novelty of technology, system complexity and type of operations of the P180, it was agreed, for functions performed by, or monitored by the SSPC, to increase requirement for values of failure probability and Software Development Assurance Levels for hazardous and catastrophic failure conditions (assuming as standard values prescribed by FAA AC 23-1309- 1C). To manage a possible single failure of a closed switch, a back-up HW protection is included in the basic design. It will activate in the event of SW malfunction causing a « stuck closed » failure. This feature was used to satisfy the Certification Agency request for a fail-safe design (e.g., an additional thermal protection included in the SSPC to provide further protection against a closed switch failure). For this specific program, keeping exactly the same cockpit interfaces for the pilot was a design requirement. This allowed to agree there was no need to further discuss human machine interface issue, such as resetting capability for SSPC essential to safety, SSPC resetting policy, need for status indication at cockpit level etc.

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