

Implementation of Modern Aircraft Daily Inspection Mode by Using Solid State Power Controller

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Abstract

This paper identifies the most promising Modern Aircraft Pre Flight/Daily Inspection (DI) Mode by using Solid State Power Controller. Daily inspection is required to be carried out as a preflight checks to ensure all systems are healthy and safe to take off. Aircraft Power Distribution plays a major role in Daily Inspection Operation. Depending on failure mode and type of operation these powers are managed by Power management system also called primary power Distribution system. This work identifies the Aircraft mode of operations and study the Daily Inspection requirement and efforts, and then implement the same by using Solid State Power Controller. Power to individual Load is provided with control and protection by secondary distribution system consisting of circuit Breaker panel and Switch Panel. Compared to circuit breakers and relays, the Solid State Power Controller (SSPC) has several functional advantages and is utilized for power control. Solid State Power Controller will keep an eye on the power distribution across the aircraft electrical system. This device's MOSFET-based Solid State Power Controller is used for switching and amplifying weak electron signals. An aircraft's Electrical systems are being monitored by using the Daily Inspection mode. In this work, MATLAB Simulink is used to implement and simulate the Daily Inspection Mode. Through a two channel ARINC 825 Serial Communication Interface, SSPCs are interfaced with the monitored parameters of the Daily Inspection Mode.

Keywords: SSPC, MOSFET, PDU, ARINC 825, DI Mode.

1. Introduction

An electrification of aircraft has been extensively researched to reduce the carbon footprints for future aircraft. The aircraft electrical system is designed with a power distribution unit (PDU) hierarchy. The system is designed so that the most critical components are the least likely to fail. To ensure aircraft serviceability and operability of specific system/items Pre-Flight inspection mostly known as Daily Inspection are carried out prior to commencing of flight. This basically involves visual and Operation check of various system/LRUs (Line Replaceable Units). Aircraft mainly consists of hydraulic system, Pneumatic system, navigation system,

Flight control system, Fuel system, Landing Gear system and Avionics systems etc. Each system required to be selectively powered ON/OFF for their Operational Check during Pre Flight Inspection. Aircraft Power Distribution plays a major role in DI Operation. Aircraft are operated with multiple hybrid power sources mostly 115V/400Hz AC and 28V DC following MIL STD 704. Depending on failure mode and type of

operation these powers are managed by Power management system also called primary power Distribution system. Power to individual Load is provided with control and protection by secondary distribution system consisting of circuit Breaker panel and Switch Panel. For protection conventional Thermal circuit breakers (CB) are widely used, having slow response time, requires manual Reset, their life is limited to number of operations, failure is prone to vibration and shock. Also, they require visible inspection in to ensure functionality hence installation limited to easily accessible areas. During DI operation number of CBs to be operated is very high and frequent consumes time and life also require additional operator to do the activities. To overcome the issues of traditional protection devices the solid state power controller technology is introduced. In airplanes, circuit breakers are being replaced by solid state power controllers. These days, SSPC boards are processor-based, offering benefits like measurement and computational precision, flexibility, and network interface (such CAN Bus, Ethernet, or MIL-STD-1553) access to an external

power management computer. Their usual energy source is an external one that typically has a voltage of 28 VDC. High dependability, extremely low power consumption, and a novel feature of remote control and monitoring using an intuitive HMI are all features of SSPC.

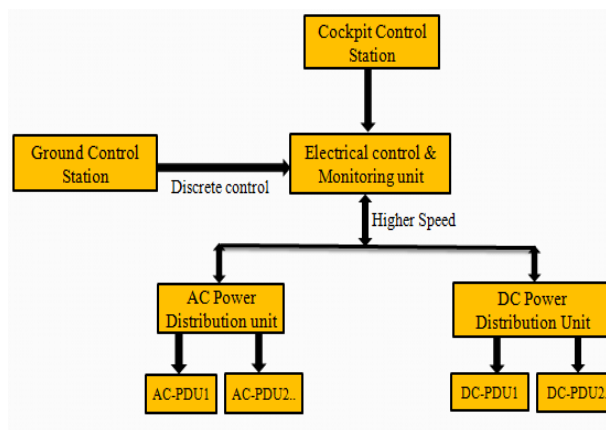


Figure 1. Overview of the work

The Electrical control and monitoring unit acquires the discrete inputs from the Cockpit and or Ground Control Station which helps to monitor the Power distribution units [Fig1]. The DI Mode Implementation by using solid state power controller is used to reduce the cost, time and the manpower. By using Grouping of SSPC channel and enabling them ON or OFF as per DI requirement is implemented with Protection to avoid the same operation occurrence in flight.

2. Objectives

This project work is identify the Aircraft mode of operations and study the Daily Inspection requirement and efforts, and then implements the same by using Solid State Power Controller. Automation of Aircraft Daily Inspection Power Distribution using Solid State Power Controller gives the following benefits: Automation, Role change, save time and cost, components life, Eliminate human errors.

3. Methodology

Aircraft Solid State Power controller Power Distribution

Circuit breakers are a common type of protection device found in power distribution units. The function of circuit breakers is identical to that of fuses or current limiters. A circuit breaker's life is

restricted to the amount of operations it can perform, its poor response time necessitates manual resets, and its failure is prone to vibration and shock. Solid state power switching devices, which offer both switching power and protection, are now available in the power distribution unit as a result of more recent innovations. The SSPC performs the duties of a circuit breaker and a relay or switch. Because SSPC boards are processor-based, they have advantages in terms of flexibility, measurement and computational accuracy, and network or data bus connectivity to an external power management computer. [12]

A. MOSFET based SSPC Automation

The Solid State Power Controller Power Distribution is necessary for the Daily Inspection Mode. In this case, we looked at the solid state power controller with sixteen channels. To function as a single channel with combined current capabilities, each individual channel can be configured to support fluctuating loads and to run in parallel with other channels. With a serial communications interface that enables a system controller to manage channels ON and OFF as well as monitor observed parameters and status, these products combine integrated current and voltage sensing.

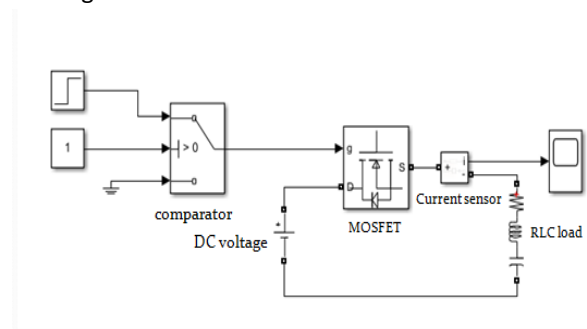


Figure 2. Screenshot of SSPC single channel

The MOSFET switch, which regulates current and is used to turn ON and OFF. It is used because they dissipate very less power and low resistance making them most efficient. The MOSFET's operation is controlled by the voltage at the gate. Here, a MOSFET's drain receives a positive voltage. The N-channel MOSFET is enhanced by the positive gate bias. A current sensor measures the output current. The current begins to flow freely between the drain and source when a voltage is put between them. The channel's electrons are

governed by the gate voltage's flow. Sixteen channels come together to form a single SSPC card in a typical application. For each channel, the comparator is used to turn the channel on or off (Fig 2). For control conditions, the comparator is connected to the MOSFET gate, input, and command. We connected every channel that has a DI Mode selection to the channel's input. The mode selection is used to turn the condition on and off. Every MOSFET is connected to every indicator. The SSPC card is monitored using the Selected DI mode LRU V/I Monitoring. The Electrical loads are calculated by using below equations in MOSFET:

$$I_{SSPC} = \frac{V}{R} \dots\dots (1)$$

$$V_{GS} = V_G - I_D R_s$$

$$V_{GS} = V_G - V_s$$

$$V_G = V_{GS} + I_D R_s$$

V_G –Gate voltage, V_s - Source voltage, I_D -Drain current, R_s -Source resistance, V_{GS} -Gate source voltage.

It is assumed that the Daily Inspection mode with SSPCs will achieve intelligent control and soft switching of the electrical loads on airplanes. Using SSPC technology lowers ownership costs and saves life cycle costs. Expanded operational range via power sequencing, staff off-loading, power budgeting, and network-controlled load management.

B. SSPC based Power Distribution Automation

In order to effectively transfer the electric power from the generating sources to the power consuming equipment in an aircraft, proper electrical distribution throughout an aircraft is essential. Aircraft Power Distribution plays a major role in DI Operation. SSPC based PDU has more reliability and accuracy. There are two types of power distribution units: Alternate and Direct current Distribution Unit. DI Mode is connected with the PDU to monitor the electrical systems of an Aircraft. Here we discussed and automated a typical Direct Current-Power Distribution Unit for the Preflight/ Daily Inspection mode Implementation.

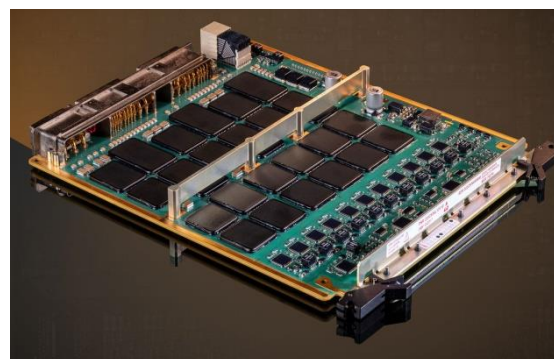


Figure3.S Aircraft PDU (Image taken from Collins Aerospace)

Fig3.Aircraft Power distribution and power management system. The primary power management system provides power to the power distribution system. The generator and inverter used in an aircraft power distribution system convert AC electricity to DC power and DC to AC power (Fig4).

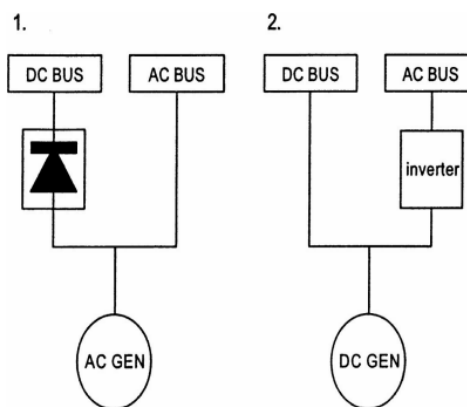


Figure 4.Block diagram of Aircraft Primary Distribution system

Each of the one or more SSPC cards that make up the DC-PDU system has eight, sixteen, or thirty-two channels. Their usual energy source is an external one that typically has a voltage of 28 VDC. We obtain three distinct current loads as an output when we divide the channels into three sections.

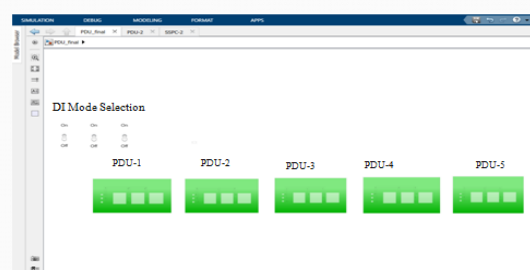


Figure5. Screenshot of DI Mode Implementation on 5 PDU (5*48 Channels) Model

Here, we take into account that the resistance of the first seven channels is five ohm, the resistance of the next five channels is two ohm, and the resistance of the final four channels is one ohm. The Power Distribution unit then yielded results of 5 amps, 15 amps, and 25 amps, respectively. Similarly, there are five automated power distribution units here (Fig 5). DI Mode is used to connect these five PDUs. Five PDUs have this DI Mode Implementation, which has (5*48) channels. Every PDU has a similar selection for DI Mode. The five PDUs will all be activated in the same mode if we turn on or off a certain selection mode. There is a distinct indicator on each power distribution unit. These Indicators are linked to the appropriate PDU. The primary Power Management system provides power to the PDU. The ARINC 825 serial communication bus is used for communicate the data to the PDUs.

C. Daily Inspection Mode of operation

The Implementation of Daily Inspection mode is depends on the aircraft electrical Power Distribution System. The DI Mode implementation by using solid state power controller monitors the failure of Aircraft Electrical systems. Daily inspection is required to be carried out as a preflight checks to ensure all systems are healthy and safe to take off. Normally 30 to 1 hr. is required to carry out all preflight checks manually requires more Manpower. An Aircraft having two Electrical modes of operation. The modes are Normal mode and maintenance mode. During Normal mode, DC-PDU shall perform it's functionality as per its configuration file. DC-PDU shall turn ON specific SSPC channels only as per the Channel list specified in configuration file. Maintenance Bus Operation should be based upon command received from Master Controller, DC-PDU shall perform the automatic configuration of maintenance loads. During DI schedule, all systems are checked for its functionality and if any maintenance is envisaged, those activities are completed. Using SSPC based system automatically you can switch to maintenance mode without selecting individual equipment.

4. Results

In all the experimental and simulation results of load voltage and SSPC voltage and SSPC current are monitored and presented. The PDU

Automation and DI Mode Implementation Plots are showed. Here five power distribution units daily inspection are presented.

Fig.5 shows the simulation results of SSPC card sixteen channel current values.

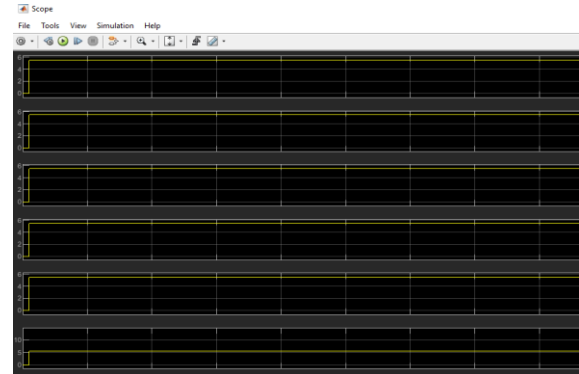


Figure5: SSPC card 16 channels current Plot result

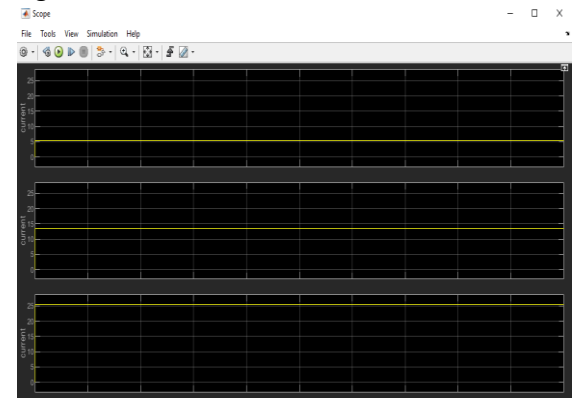


Figure6: Power distribution unit current plot (48-Channel)

Fig.6 shows the simulation results during the channel Resistance (5Ω, 3Ω & 1Ω) and DC load 28VDC.



Figure7: DI Mode implementation on PDU Plot

Fig.7 shows DI Mode Implementation on Power Distribution Unit model Plot results

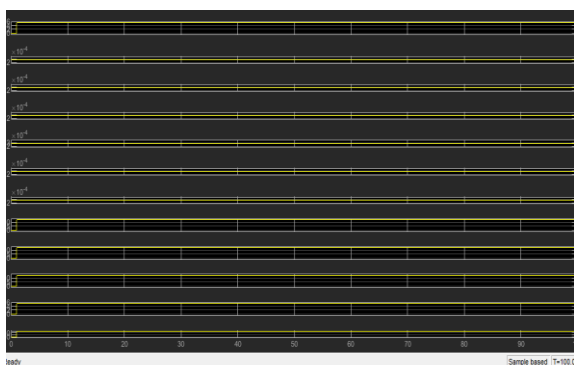


Figure8: DI Mode Implementation (5*48-CH) plot

Fig.8 shows DI Mode Implementation on SSPC card 5th channel connected with third set of channel Results.

From the data presented, it can be concluded that the Daily Inspection Mode by using SSPC simulation model is implemented with different kinds of loads (resistive and capacitive).

5. Discussions

In this paper, the Implementation of Modern Aircraft preflight/Daily Inspection Mode by using solid state power controller has been presented. The SSPC internal structure serves as the foundation for the first automation approach, which is followed by the Power Distribution Unit and, lastly, the Implementation of the Aircraft DI Mode. Every aircraft must undergo a daily examination in preflight condition. It increases the lifespan and efficiency of the aircraft systems and guards against LRU failure. Using a solid state power controller to implement the daily inspection mode has the advantages of saving money, time, and components' lives. It also eliminates human mistake, allows for role changes, and automates processes. Model simulation is a more effective way to enhance SSPC Automation and address integration issues during the development stage.

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