

Dual Redundant Power supply for More Electric Aircraft Applications

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ABSTRACT: In the aerospace applications the flight control system of aircraft, launch vehicles or missiles use Electro-Mechanical Actuators (EMA) for controlling the orientation of aircraft, landing gears, and braking systems. EMA provides high precision, high power supply to weight ratios and motion velocities with a reduction in the size of the equipment that requires an only quarter of the space to deliver the thrust. This demand for electrification in Aircraft control surfaces leads to a new concept More Electric Aircraft (MEA) provides technical and economical improvements over mechanical, hydraulic and pneumatic systems. This paper recommends a new method, dual redundant power inverter system to overcome the problems occurring while using a single power supply system in the aircraft.

KEYWORDS : Electro-Mechanical Actuator (EMA), Dual redundant, More Electric Aircraft (MEA).

I. INTRODUCTION

Actuators are one of the key components contained in any industrial system. Electromechanical actuators are widely used in the industry for a variety of applications. More electric aircraft is a concept which involves the maximum utilization of electrical technology in control surfaces with expertise mastered control architectures. In such flight control surfaces, EMA plays a huge role to control the direction of aircraft. A subsystem of an EMA includes power electronics circuitry, controller, a BLDC drive, ball screw mechanism for position detection, and its associated components. The fundamental structural blocks in EMA are power converters and BLDC drive, designing of these components became a challenge. A simple fault occurrence in any subsystem of electromechanical actuator leads to the whole outage in the system and many lives would be at risk. Aircraft applications require safety and accessibility so, "redundancy management" is necessary. Dual redundant logic consists of two modules consisting of power inverter stage and BLDC motor windings. If any fault occurs, the other alternative module will drive the whole actuation system maintaining the reliability. The DC motor is the simplest, efficient motor among various electromechanical actuators.

DC motors are restricted in reliability and robustness due to wear of the brush and commutation mechanism. In industrial applications where a high level of reliability and robustness is required, DC motors have been replaced by brushless motors and other types of motors having no mechanical commutator. Inverters are the alternative source of power when normal power fails. Inverters consist of a speed-governed dc motor, an armature and brush assembly, and a permanent magnet inductor-type ac generator in one unit. The armature and the permanent magnet rotor mount on a common shaft. The dc motor of most aircraft inverters is essentially a shunt-wound motor. High starting currents and a low rate of acceleration (because of low torque at starting) are characteristic of shunt-wound inverters. The larger inverters have a series-starting winding to help avoid the effects of these undesirable characteristics. When the inverter reaches rated speed relays disconnect the series-starting winding and connect the dc input to the dc motor armature and the shunt winding. Then, the inverter operates as a shunt-wound motor having desirable constant-speed characteristics.

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II. RELATED WORK

Reliable electro-mechanical actuators in aircraft ^[2] by A. Garcia; etal (2008) proposed this paper to implement the safety requirements of electro-mechanical actuators in aircraft applications, and Its goal is to present the suitability and reliability of actuator systems, as well as electric motors and power converters. The benefits are a decrease in maintenance effort and weight, and an increase in inefficiency.

A dual redundancy technique for the electromechanical actuation system applied to launch vehicles paper ^[3] by Jaiso H; etal (2011) implements, an Electro-Mechanical Actuator (EMA) based position control system with redundancy technique. The servo system is made of two chains, a prime chain and a redundant chain, which contains the position servo system of the EMA. Only one chain works at a time, probably the main chain operates during the normal state of the system. A new and simple fault detection and isolation (FDI) system is being established, which will be monitoring the prime chain endlessly.

A Review of More-Electric Aircraft ^[1] by Abd El-hafez AA and Forsyth AJ proposes the paper that More-Electric Aircraft (MEA) underlines the utilization of the electrical power to power the non-propulsive aircraft systems. Implementing the MEA achieves numerous advantages such as enhancing the aircraft performance and reducing the operating and maintenance costs.

Design of new switched stator BLDC drive to develop the efficiency of an electric vehicle ^[5] by Ravikumar BV and Sivakumar K proposed that Switched stator BLDC motor is proposed for an electric vehicle to develop the energy efficiency of the vehicle. The construction of SS-BLDC and its assembly with the wheel is presented in detail. The complete vehicle model with SS-BLDC, battery, vehicle dynamics and controller model are built using MATLAB/SIMULINK. The simulation results show that the power and energy consumed by battery in the proposed configuration are less associated to the conventional configuration.

III. PROPOSED SYSTEM

The old systems are used Single inverter power supply which faces several problems like if any damage in single inverter total systems goes down, and it generates more heat. This proposed system contains dual redundant power inverter, if any problem happened in one supply inverter then automatically the second inverter turns on. Therefore, the system will work continuously without any issue. So that the heating problem will be also reduced. This is a working model using Atmega microcontroller interfaced with a Bluetooth module that acts as a switch and a motor driver connected with two brushless motors is shown in Fig 1. A 12v DC power supply is been connected with a motor driver and the Atmega microcontroller. The Bluetooth as a switch controls the whole system manually by changing the primary and redundancy motor on according to the instructions by the user.

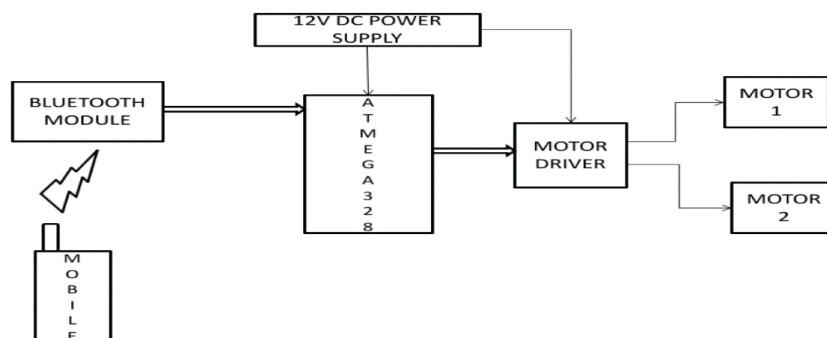


Fig 1. Block Diagram of proposed MEA

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ATMEGA328P is a high performance, low power controller from the Microchip. ATMEGA328P is an 8-bit microcontroller built on AVR RISC architecture. It has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM). This mechanism exhibits if the electric supply provided to the micro-controller is removed, even then it can store the data and can deliver outcomes after providing it with the electric supply. Moreover, ATmega-328 has 2KB Static Random-Access Memory (SRAM). These are the configurations of the microcontroller used in the below mentioned circuit diagram in Fig 2.

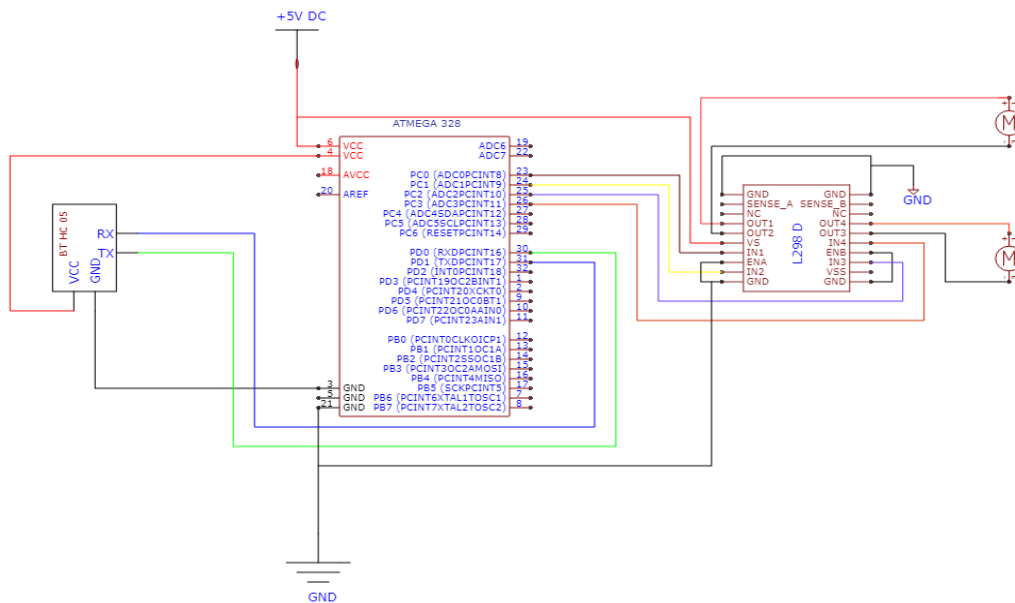


Fig 2. Circuit Diagram

IV. SIMULATION RESULT

The code for this Dual redundant inverter is been uploaded and compiled to Arduino IDE to get the final simulated results. Arduino IDE is the open-source platform for compiling and writing the code into the Atmega microcontroller.

Healthy/section	Faulty Section	Recommended path
<i>Case-1</i>		
PI-1 → W1	If Fault at W1	PI-1 → W2
PI-1 → W2	If Fault at PI-1	PI-2 → W2
<i>Case-2</i>		
PI-1 → W1	If Fault at PI-1	PI-2 → W1
PI-2 → W1	If Fault at W1	PI-2 → W2
<i>Case-3</i>		
PI-1 → W1	If Fault at both PI-1 and W1	PI-2 → W2

Table I. Possible Switching cases

The redundancy logic to this system is limited for only one fault in each module. Primary chain is always in operation under normal conditions. If any fault occurs, then only redundant chain takes the service. If there is a fault in PI-1, the system can run without interruption either through PI-2, W2 and PI-2, W1. Of course, the latter is preferred because if the second fault occurred in W2, and then the whole system will be out of redundancy. The probability to occur faults in various available subsections is presented in the table for different cases and the possible recommended outcomes are displayed in Table 4.1 given below.

V. CONCLUSION

The ongoing effort to replace the present mechanical, hydraulic, pneumatic drives has led to improved reliability, maintainability and cost-effectiveness. MEA represents an evolutionary implementation of the all-electric drive in aerospace systems and has shown its popularity. An electromechanical actuator comprised of position control system with the dual redundancy technique applied to both BLDC motor and power inverter has been designed and simulated, and results are presented.

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