PWM Controller for MAV Morphing Application

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ABSTRACT

Micro Air Vehicle (MAV) is a type of Unmanned Aerial Vehicle (UAV) which has size restriction. MAV operation can be controlled by remotely or autonomously. Instead of using servo mechanism we have used Macro Fiber Composite (MFC) as the control actuator for the control surface movement of MAV for morphing applications. The working voltage of MFC ranges from -500V to 1500V. Radio Control (RC) transmitter transmits the controlling signal and the signal is received by receiver antenna as radio signal. The Pulse Width Modulation (PWM) signal is fed to MSP430G2553 microcontroller to convert into digital frequency signal. The output of microcontroller is fed to different isolation switches for control actions. The control action involves the switching action between two isolation switches with different voltage levels at each time. The controller takes the PWM signal and connects the actuator either straight connection or crossover connection as per the reference signal from the transmitter for MAV to fly in synchronous or asynchronous flight mode.

Keywords: MAV, MFC, Isolation switches.

INTRODUCTION

In Soldiers, Special Weapons And Tactics (SWAT) teams, and natural disaster first responders are examples of teams of people operating in dangerous and potentially hostile environments who quickly need information about their local environment. These personnel often quickly need aerial imagery of their environments to answer relatively simple questions such as, "Is my path blocked?" or "Is there a threat on top of that building?" The use of Micro Air Vehicles to support such personnel has become common place in the military operations .MAV is a class of UAV that are used in such operations. A new trend in MAV community is to take inspiration from flying insects or birds to achieve flying capabilities [1]. For facilitating the flapping action, piezoelectric actuators are favourable due to their low power consumption and ease of integration. They are highly compact yet very powerful. Since the conventional piezoelectric materials are stiff and brittle, they are not suitable for morphing applications involving large deformations. Hence, highly flexible piezoelectric fiber composites called MFCs are used [2]. For typical MAV applications, the driving force required of an actuation of MFC implies an operational voltage nearing its capacity, which is -500 and 1500 V AC. This range of voltages has to be generated from a 5V DC source, which is the typical electrical source presented in micro-robotic platforms. Super capacitors, solar cells, fuel cells and lithium batteries are the most compact energy sources available in the market which can generate output voltage up to 5V. The high voltage drive circuitry should generate a time-varying signal to enable self-actuated MAV. Moreover, due to limitations of payload of the morphing wing MAV, the high voltage circuit should also be very light in weight with extremely low current drain which in tum leads to smaller power consumption, as required. This paper is mainly focused on the promising design and simulation of a high voltage wireless controller which can provide a high voltage

(-500 to l500V) for MAV applications. Entire circuit is constructed using Isolation switches and high voltage switching devices. The isolator is electrical switch which separates a part of the electrical power system normally at offload condition. An opto isolator is a type of isolator which is used in this work. An opto-isolator is a component that transfers electrical signals between two isolated circuits by using light. PWM methods are generally used for the control of the controller.

LITERATURE SURVEY

A lot of research works are going on related to the design and fabrication of drive circuit for morphing wing MA V. Here the author has replace MAV control surface with MFC actuator. Its working voltage is -500V-1500V. Controlling signal is transmitted by transmitter to receiver. Received PWM signal was converted to 0-5V DC voltage with the help of PWM- voltage converter. To provide required voltage for MFC, Flyback DC-DC converter was used which is simulated in MATLAB simulink [1]. In this paper, the author proposed novel material for MAV structure and actuator flapping. MAV will carry On-board battery which provides small DC input voltage. This Lipo battery gives 5V input. This 5V DC is converted into 200V by voltage multiplier circuit. This 200V is converted into 1500V by using Flyback DC-DC converter. IGBT H-bridge and high voltage flyback converter was designed and simulated using MATLAB simulink [2]. In this paper MFC actuators are used for aerodynamic shaping of aircraft wings. Here the servos are replaced with on-board 'MFC driving circuit'. Amplifier is used for the generation of required voltage for MFC operation from small batteries. Voltage drive circuit helps to adjust this voltage before giving to MFC actuators [3]. Communication system and controlling of Unmanned Ground vehicle (UGV)-MAV are discussed in this paper. The X-bee transceivers model is used for the communication which provides human control and computer switching [4]. This paper gives the detailed survey on designing of control system and dynamic modeling of morphing wing aircraft structures. The morphing wing is build by using Lagrange method by considering of energy parameter. For the control allocator design, Pseudo inverse method and for decoupling system, two active disturbance elimination controllers were used [5]. In this paper author designed new multilevel inverter (MI) which uses several low level input voltages at its receiver. In this work they used crossover switch cell (CSC) MI to produce required voltages. It contains eight switches, DC capacitor and DC power supply. DC capacitor was used to reduce the number of DC supplier [6]. In this paper, author used shunt series monolithic PIN diodes. To produce high isolation in it's off state and low insertion loss. Different solid state circuit also studied in detail which is used for switching purpose. Different solid state circuit also studied in detail which is used for switching purpose. PIN diode shunt series arrangement helps in improvement of circuit performance [7].

BLOCK DIAGRAM

PWM or Pulse Duration Modulation (PDM) is a modulation technique used to encode message into pulsating signal.

In this work first we generate the PWM signal using RC electronics. The controlling signal is sent through the RC transmitter. The RC transmitter sends the data to the RC receiver by generating a modulated radio frequency carrier. The receiver side an antenna through which it receives the radio signals. The receiver detects data from the modulated carrier, decodes and delivers it to the respective servos shown in fig 1.1.

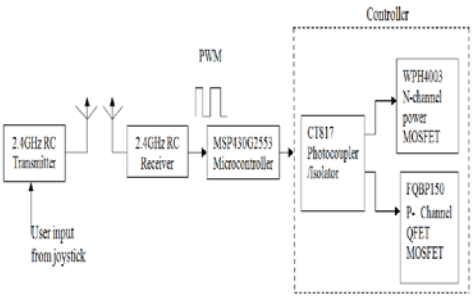

Fig 1.1: Functional block diagram

In this project the work involves developing a PWM based wireless controller for switching operation of control actuator wing. The basic block in this project involves isolation switches for -500v to +1500v and

RC PWM switch using MSP430G2553 micro controller. The isolator is electrical switch which separates a part of the electrical power system normally at offload condition. The PWM signal is fed to the microcontroller to convert into the digital frequency signals. The embedded code is developed for the micro controller converts the received PWM signal into frequency signal. The output of micro controller is fed to the different isolation switches for the control action. The control action involves the switching action between two isolation switches with different voltage levels at each time. The controller takes the PWM signal and connects the actuator either straight connection or crossover connection as per the reference signal from the transmitter. Fig 1.2 shows the hardware implementation of the circuit.

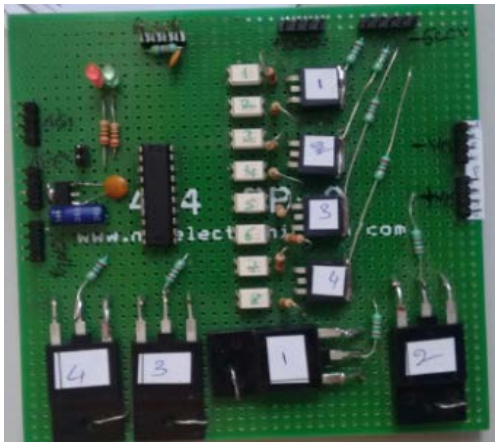

Fig 1.2: Hardware PCB

RESULTS

The generated PWM signal from microcontroller was measured using DSO which is shown in 2(a) shows a PWM signal for frame rate of 50HZ. 2(b) shows PWM signal for 1ms ON time and 2 (c) shows for 2ms ON time.

Fig 2(a): PWM signal with frame rate 50HZ

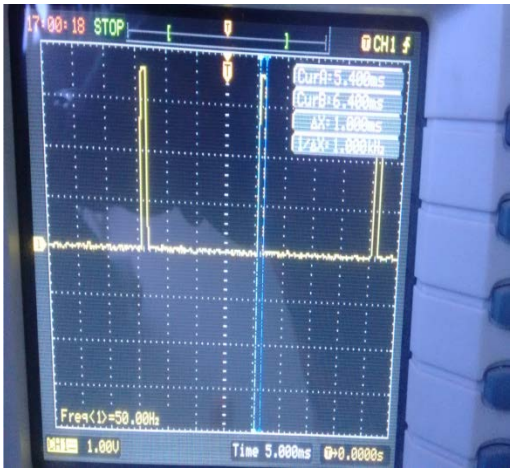

Fig 2(b): PWM signal with 1msec ON time

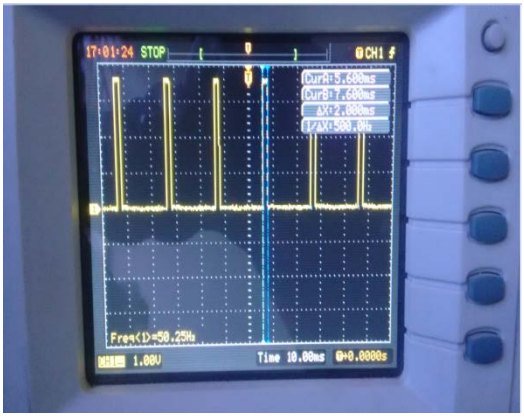

Fig 2(c): PWM signal with 2msec ON time

CONCLUSION

MAV is a class of UAV having size restriction of 15cm. This paper described the design of the high voltage carrying circuit using isolation switches for morphing wing application. This circuit is suitable for providing proper actuation voltage for the material. For the proper control of the wing PWM technique was used. And also discussed the partial results which contain PWM generation using MSP430G2553 for basic testing of the hardware.

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