

DEVELOPMENT OF A PWM PRECISION SPRAYING CONTROLLER

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ABSTRACT

This paper presents a new pulse width modulation (PWM) controller for unmanned aerial vehicle (UAV) precision sprayer for agriculture using a TL494 fix-frequency pulse width modulator together with a data acquisition board and developed software. An UAV can be remotely controlled or fly autonomously by pre-programmed flight plans. The PWM controller was implemented through the guidance system on the UAV with control commands sent between the helicopter and the ground control station via a wireless telemetry system. The PWM controller was tested and validated using LabVIEW 8.2. Several analyses were performed in a laboratory to test different control signals. The results obtained with the PWM controller on the UAV precision sprayer has promise as a technique to higher precision of spray applications that will improve efficiency of pesticide application, especially in crop production areas.

Study Objective

The study was focus on developing a PWM controller to apply the UAV precision sprayer.

PWM controller

We have developed a PWM controller based on the TL494 (Texas Instruments, Dallas, TX), which is a fix-frequency pulse width modulation control circuit.

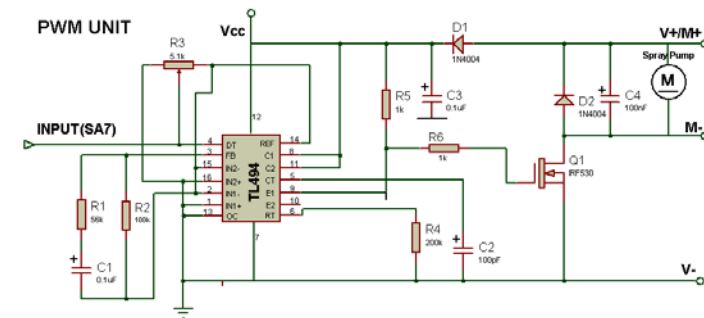
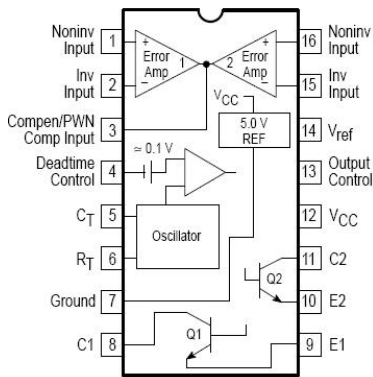
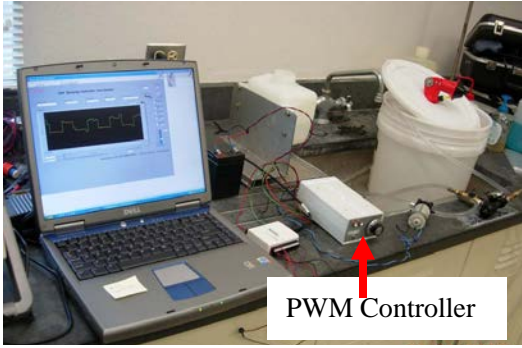


Figure. 1 Block diagram of TL494

Figure. 2 The peripheral circuit of TL494

Performance of spraying system

Based on NI USB 6008/6009 DAQ[®] and LabVIEW[™], the test system basically consists of the following components: A Micronair Ultra-Low-Volume (UAL) –A+ nozzle was used to evaluate for flow rate. A chemical tank to hold the liquid to spray. A compact DC pump to pump the liquid from the tank to the nozzle. A pressure gauge was used to check the valves for nozzles to prevent them from dripping. A PWM controller was used to control the speed of the DC pump and hence the spraying rate of the nozzles. A data acquisition card with a 12-bit ADC was used to control the PWM controller.



PWM Controller

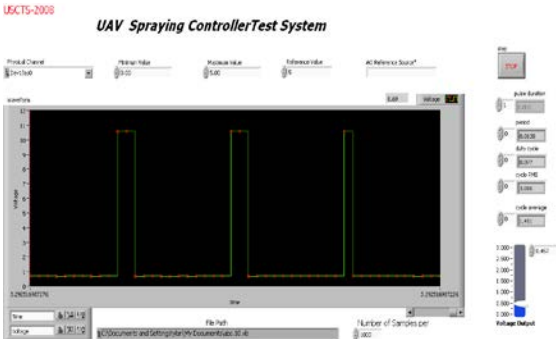
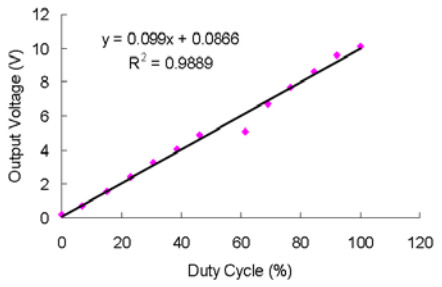


Figure.3 PWM controller test system

Figure.4 The software for PWM controller.

Results

The duty cycle exhibited different values at switching control voltage values ranging from 0 to 3.3 V. They were highly correlated with a strong linear relationship ($R^2=0.9965$).By controlling the duty cycle via the input voltage, the output voltage could be controlled due to the linear response between duty cycle and output voltage (Fig. 5). To confirm the functionality of the PWM unit, the relationship between flow rate and duty cycle was tested. The flow rate from the PWM controller test were found to have a strong linear relationship ($R^2=0.9836$) with duty cycle (Fig.6).



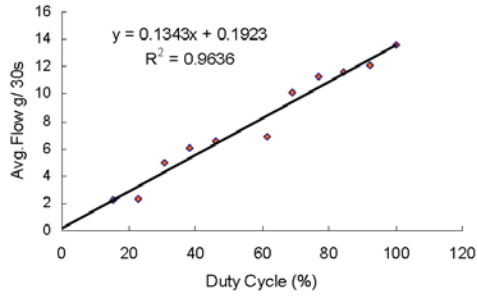


Figure.5. Relationship between duty cycle and output voltage from PWM controller. PWM controller

Figure.6. Relationship between duty cycle and flow amounts from PWM controller

CONCLUSIONS

The performance of the PWM controller designed in this study was tested. The controller could adjust the duty cycle in PWM signal using TL494 which is a fix-frequency pulse width modulation control circuit. The relatively strong correlation between control voltage and duty cycle is about ($R^2=0.9965$), control voltage and output voltage is about ($R^2=0.9935$), flow amount and duty cycle is about ($R^2=0.9636$) that the PWM controller has promise for precision spraying. The development of a PWM controller for UAV precision sprayer has a great potential to enhance the efficiency of pesticide applications.