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Computerized Payload (Camera) Axis Control System for Autonomous Flight Vehicle

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***Abstract*— The aim of this research considered in this paper is to implement for PC based control system for two axes camera platform. Camera is used as a payload and two servo motors are used to adjust the camera lens in two axes. This paper describes design and implementation of PC based payload (camera) control system for flight vehicle to get the desired target photo. The user interface program was designed using C sharp language and user can control the desired camera axes from PC to PIC microcontroller via RS232 protocol. Servo motors are applied as powerful mainly drive component of the payload for control purpose. The control system is based on microcontroller PIC16F877A. The C language is used for this control system.**

***Keywords*— PIC, microcontroller, C sharp, PWM, servo control**

I. Introduction

Autonomous flight vehicle may be used for a variety of civilian and military purposes, of which rescue operations in dangerous areas and surveillance may be mentioned as obvious examples. Such aircraft have already been implemented by the military for recognizance flights. Further use for autonomous flight vehicles by the military, specifically as tools for search and rescue operations, warrant continued development of autonomous flight vehicle technology. Due to attraction of autonomous flight vehicle application, its technology and development of the autonomous flight vehicle, such as control and guidance, payload development and on board computer system, etc.

This paper focused on design and implementation of payload (camera) Pan-Tilt unit control system for autonomous flight vehicle. Servo motors are the mainly drive components of the Pan-Tilt axes. To drive these motors in moving or rotating smoothly, the key technology is to generate the driving PWM signals. For PWM generation, PIC16F877A was used in this project. PIC16F877A have built in PWM modules. This paper has just provided a friendly interface to control two axes and the control unit runs in open loop type control only. The system was designed so that while pan axis is limited to angles between -45 deg and +45 deg and tilt axis is limited to -45deg and+45deg. Therefore, the objective of this paper is to deliver a control command to move vehicle's payload (camera). Normally, the system block diagram is shown in Fig. 1.This paper is just only contented with the PC based camera axes (Pan-Tilt) unit control system via RS232 protocol without RF transmitter/receiver module and the user interface program was designed using C sharp language.

II. System Hardware Components

The overall system configuration is briefly represented in this section and the hardware used in this research and the physical integration of the components are also described.

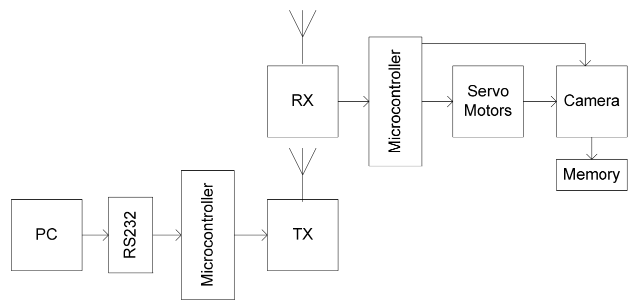

Fig. 1 Block diagram of the system

A. PIC Microcontroller

The PIC 16F877A 8bit microcontroller was chosen to obtain the command data from PC and control the motor on UAV payload. This microcontroller has a 25MHz processor (the current compiler runs the processor at 20MHz, 33input/output I/O pins, (8k*14wards) of Enhanced Flash program memory, (386*8bytes) of RAM, (256*8bytes) of data EEPROM. The PIC does not have an operating system and simply runs the program in its memory when it is turned on. This PIC microcontroller has several hardware features that are very useful for a UAV in this paper, such as universal synchronous/asynchronous transmitter/receiver, timers and (capture/compare/pulse width modulation (CCP) channels.

B. Servo Control

The servo control board is homemade prototype. The processor is PIC16F877A with two channels PWM signal output. It can command two servos with RS232 serial port. PWM signal is used extensively on DC servo control. A square wave is outputted 50 times per second. The width of the square wave decides the horn of the servo oscillating angle. When the width of the square wave equals 1.5milliseconds, the horn of the servo keeps on neutral (0 degree) position. The width of square wave will change from 1 to 2 milliseconds and the horn of servo will rotate amount -45 to +45 degree as shown in Fig. 3. Fig. 2 shows the ideal of the servo platform structure (Pan-Tilt) camera axes. The axis of servo 1 is parallel to the Φ-axis of the vehicle and the axis of servo 2 is parallel to the θ-axis of the vehicle.

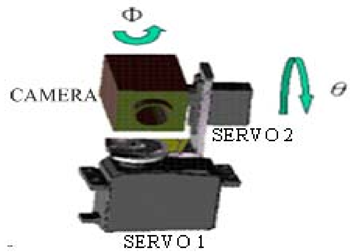

Fig. 2 The concept of servo platform

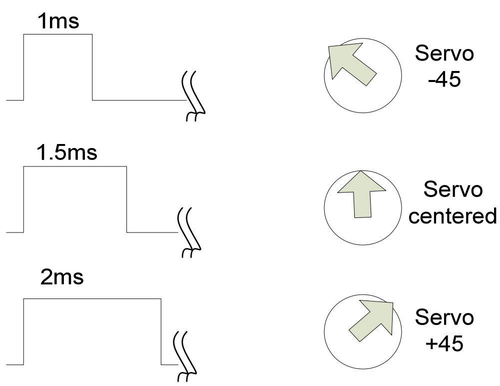

Fig. 3 Relationship of pulse width and axis output of motor

C. Circuit Description of the System

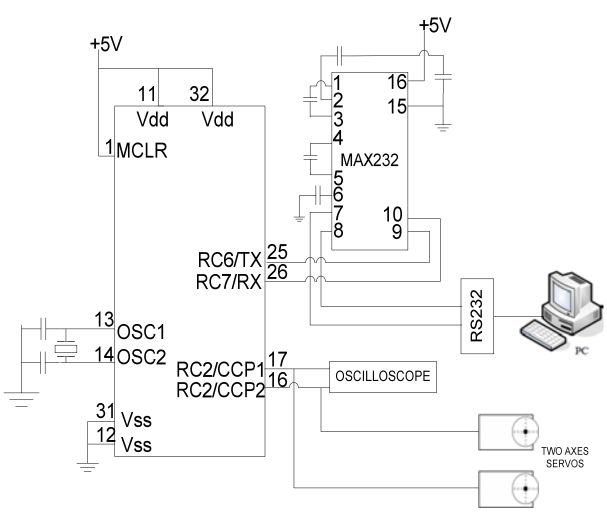

Fig. 4 Circuit diagram of the system

Fig. 4 shows the schematic diagram of PC based two axes camera control system. It mainly contains personal computer, RS232 port, PIC 16F877A, MAX 232 and two servos. PC is used as user interface window. User can move the track bar and relative position command of servo motor will transfer from PC to PIC via MAX-232. PIC generates two PWM channels to control two servos position corresponding to user command.

III. Software Interfacing For Camera Axis Control

This section describes the user interface program design and C code that was written to interface the microcontroller with the hardware used in this project.

A. CCS C Compiler Feature

The CCS, Inc. has developed a C compiler called the PCWH for the PIC 16F877A microcontroller. This compiler is easy to use with CCS's Windows based IDE (integrated development environment) and its "C aware" editor. This is not an ANSI compliant C compiler and it has some differences from a traditional C compiler because of separate code and data segments in the PIC hardware. This compiler does have some of the standard ANSI library and math functions and has many extensions that are useful when working with the PIC hardware. The compiler has built-in libraries for working with RS232 serial input and output, digital input and output, and precision delays and makes hardware features such as timers and A/D conversion easy to use with C functions. It also supports 32 bit floating point numbers and floating point math, which is very important for the calculations used in the control algorithm.

B. PWM mode in CCP module

In this paper, PWM mode is used and the following steps configure the CCP module for PWM operation.

- Establish the PWM period by writing to the PR2 register.
- Establish the PWM duty cycle by writing to the DCxB9:DCxB0 register.
- Make the CCpx pin an output by clearing the appropriate Tris bit.
- Establish TMR2 prescaler value and enable Timer2 by writing to T2CON register.
- Configure the CCP module for PWM operation

The first step is to write the PWM period to PR2 register. The desired PWM period can be calculated using the following formula:

PWM period= [(PR2)+1]*4*Tosc*(Timer2 prescaler value)

The proposed system requires the 4ms period and since selected PIC 16F877A clock frequency is 4MHZ that means Tosc is 0.25us and the selection of timer2 prescaler value is 16,PR2 value is

PR2= [Tpwm/(4*Tosc*TMR2 pre)]-1=0xF9h=249

So, PWM period can be set up by using the following codes.

Setup_timer_2_(T2_DIV_BY_4,249,1);

Second, the PWM duty cycle is established by writing to the DCxB9:DCxB0 bits.

The desired PWM duty cycle can be calculated using the following formula:

PWM duty cycle= (DCB9:DCB0)*Tosc*Timer2 prescaler

The value of DCB9:DCB0 are calculated by using the following equation:

DCB9:DCB0=Dpwm/(Tosc*TMR2ps)

For 1ms, PWM duty cycle that drives the servo motor-45degree, the duty cycle register value is

DCB9:DCB0=0xFAh=250

So, PWM duty cycle can be set up by using the following codes.

Set_pwm1_duty(250);

For 1.5ms, PWM duty cycle that drives the servo motor -45degree, the duty cycle register value is

DCB9:DCB0=0177h=375,

So, PWM duty cycle can be set up by using the following codes.

Set_pwm1_duty(375);

For 2ms, PWM duty cycle that drives the servo motor +45degree, the duty cycle register value is

DCB9:DCB0=01F4h=500,

So, PWM duty cycle can be set up by using the following codes.

Set_pwm1_duty(500);

According to the above procedure, the duty cycle register values are calculated to get the required PWM duty cycle that drives the servo motor and these values are shown in Table1.

TABLE I
DUTY CYCLE AND ASSIGNMENT OF OUTPUT DATA

Data from PC	Duty Cycle Value	Pulse Width of PWM	Servo Degree
1	250	1ms	-45
2	252	1.008ms	-44
-	-	-	-
46	375	1.5ms	0
-	-	-	-
90	498	1.992ms	+44
91	500	2ms	+45

C. Serial Communication Protocol(RS232)

The USART (universal synchronous\asynchronous transmitter\receiver module) can interface to PC's and modems, A/D, D/A and EEPROM devices. Data formats acceptable to the USART are: 8 or 9 data bits; none; odd or even parity. In asynchronous mode, the USART can handle full duplex communications. There are preset functions which speed up application by writing the following code:

```
#use rs232(baud=9600,xmit=PIN_C6,rcv=PIN_C7)
#use Delay (Clock=4000000)
```

D. System Configuration for User Interface

The developed experimental system for user interface is shown as Fig. 5. It consists of a personal computer, RS232 communication port, circuit board and two channels PWM signal oscilloscope display. User interface program is designed using C sharp language.

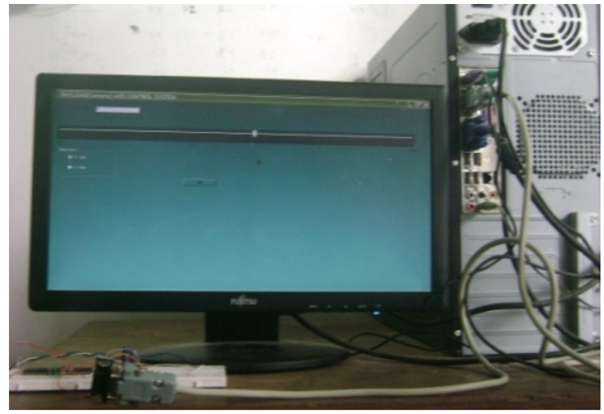

Fig. 5 User interface development system.

E. Servo Angle Control Program Description

The user interface is shown in Fig. 6. On the main screen, the user is allowed to control the current servo angle by just clicking at a given angle or by dragging the angle indicator. It is possible to control 2 servos using track bar and box located at the bottom left corner named" select axis". It is possible to set up among the COM number and the Baud Rate that user wants to communicate with PIC. In this paper, the Baud Rate is set to 9600bps.In Fig. 6, each motor mapped to a horizontal track bar. By dragging the track bar, the mapped servo motor moves to relative angle degrees. The function of developed interface is illustrated as follow.

- Select Axis

  At the bottom left corner of the main screen, user is allowed to select two axes (X and Y).

- Track Bar

  By moving the track bar, user can control the desired servo angle from -45 to +45 degrees. The message located at the left upper side of the main screen shows the current servo angle position.

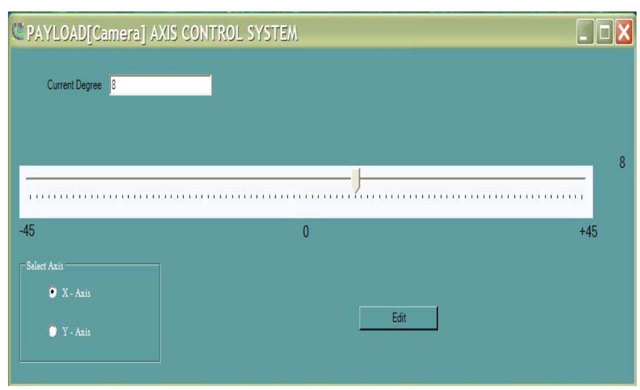

Fig. 6 User interface window

F. PC Program Analysis

To interface PC and PIC, the PC end program was designed using C sharp. The user interface program flowchart is shown as Fig. 7.

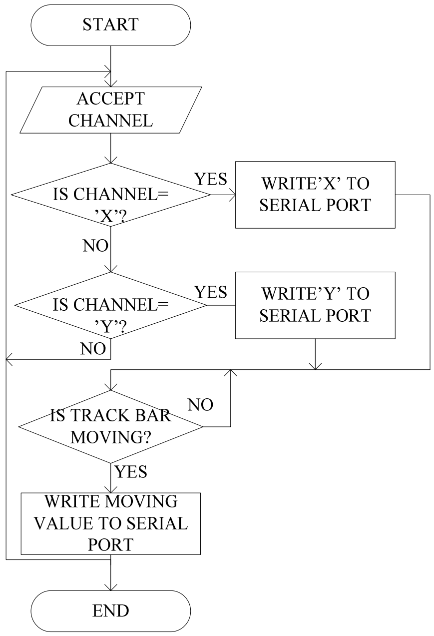

Fig. 7 User interface program flowchart

G. *PIC Program Analysis*

PIC received the commands from PC; it consists of two parts; main program and two-channel PWM signal output interrupt subroutine. The main program flowchart is shown as Fig. 8 and the PWM signal output interrupt subroutine is shown as Fig. 9.Interrupt subroutine is for X-axis but the flow chart for Y-axis is the same as this procedure.

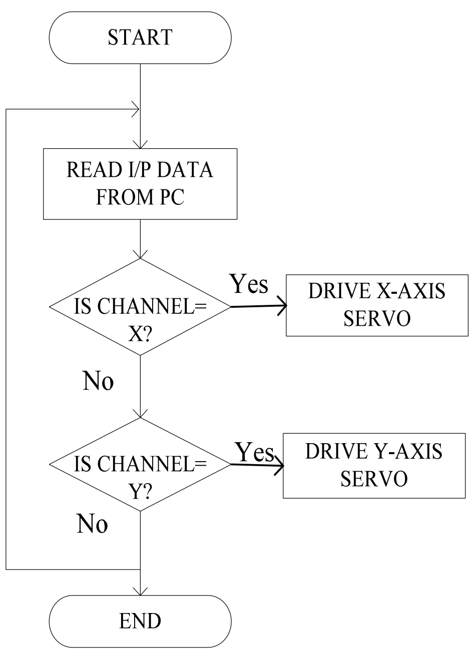

Fig. 8 Main program flowchart

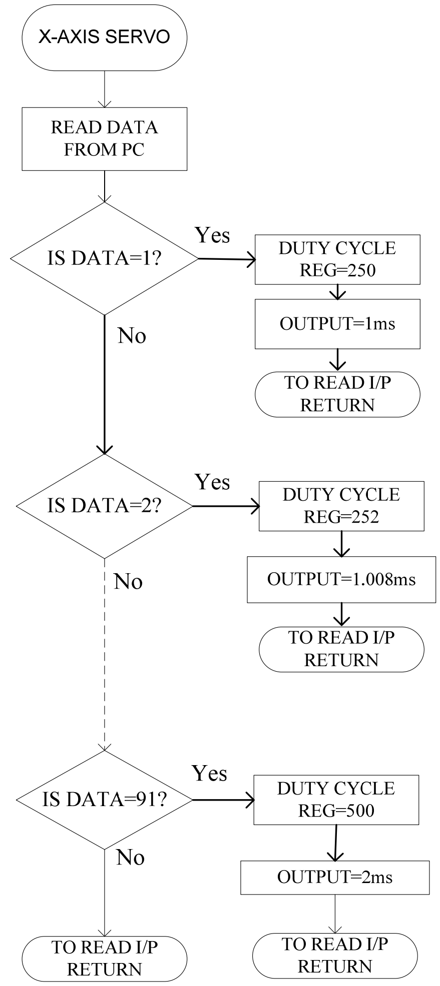

Fig. 9 Subroutine flowchart

IV. Tests And Results

Fig. 10 shows circuit design of simulation software. Fig. 11 and Fig. 12 show the simulation result of two channels PWM output corresponding to user command to drive two servo motors.

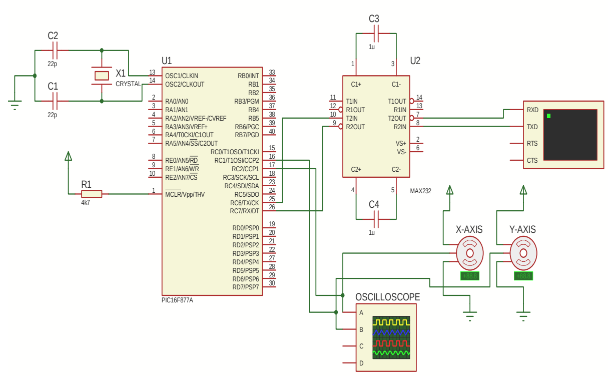

Fig. 10 Circuit design of simulation results

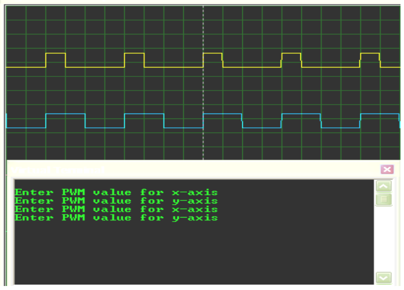

Fig. 11 Simulation in Proteus software (PWM1=1.008ms, PWM2=2ms)

In Fig. 11, PWM channel one is 1.008ms and channel two is 2ms. PWM channel one drives servo motor to -44 degree. PWM channel two drives servo motor to +45 degree.

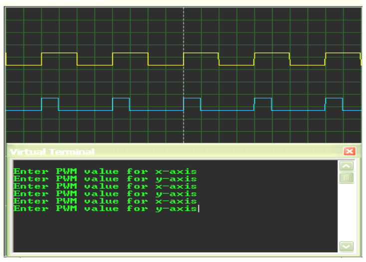

Fig. 12 Simulation in Proteus software (PWM1=1.992ms, PWM2=1ms)

In Fig. 12, PWM channel one is 1.992ms and channel two is 1ms. PWM channel one drives servo motor to +44 degree. PWM channel two drives servo motor to -45 degree.

The proposed system is implemented in hardware and oscilloscope results obtained are shown in Fig. 13 and Fig. 14.

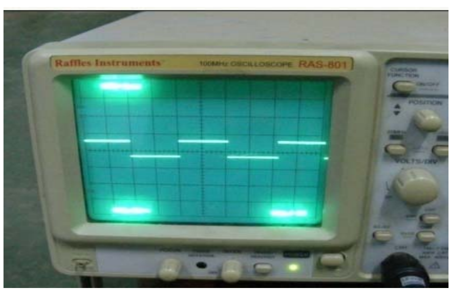

Fig. 13 One channel PWM in oscilloscope

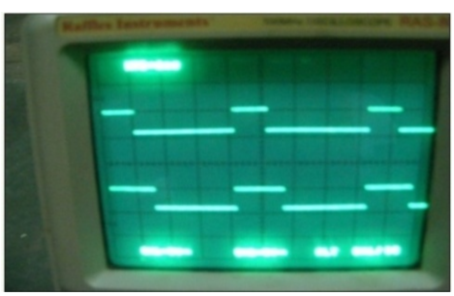

Fig. 14 Two channels PWM in oscilloscope

In Fig. 13, PWM channel one is 2ms and it drives servo motor to +45 degree. In Fig. 14, PWM channel one is 1ms and it drives servo motor to -45 degree. PWM channel two is 2ms and it drives servo motor to +45 degree.

V. Conclusions

Two channels PWM signal generation according to user interface window for camera axis control system is proposed in this paper. PIC16F877A microcontroller can generate two channels PWM signal to control two axes camera unit. In this paper, servo motor can rotate left and right direction with one degree angle resolution.

User interface program is developed to benefit the position control in this paper and the interface program is designed using C sharp language. The proposed system can be used to control robotic application. Integrating UHF RF transmitter and receiver module to implement camera axis control system with wireless link between ground station and the vehicle is future work of the proposed system.

Acknowledgment

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