UNIVERSITY OF DERBY

Faculty of Arts, Design &Technology

EXAMINATION PAPER

BSc (HONS) ELECTRICAL & ELECTRONIC ENGINEERING
BSc (HONS) MUSIC TECHNOLOGY & AUDIO SYSTEMS DESIGN
BSc (HONS) SOUND, LIGHT & LIVE EVENT TECHNOLOGY
LEVEL SIX

EMBEDDED SYSTEMS
6EJ005

DATE: SUMMER 2006

TIME ALLOWED: 2 HOURS

Instructions to Candidates

1. Answer all THREE questions.
2. All questions carry equal marks.

DO NOT TURN OVER UNTIL INSTRUCTED

Question 1

A model boat is controlled by a PIC 16F873A microcontroller, as seen in Fig. Q1.1. The boat has two propellers, and is able to steer by driving one faster than the other. Each propeller is driven by a reversible DC motor. These have a rated maximum supply voltage of 9V, but for this application their torque is still adequate down to 4.5V. There are two tilt switches on the boat, which detect whether it is tilted too far from the horizontal. If the tilt is too great, the motors must be switched off. Each acts as a SPST (single pole single throw) switch, which is closed when no tilt is detected.

Draw a design for the microcontroller circuit, in the form of a detailed circuit diagram. Include all aspects necessary to make a complete and working circuit. The L293D driver interface i.c. (integrated circuit), as shown in Fig. Q1.2 is available for use. You may also include the use of other i.c.s or circuit elements.

Explain briefly but clearly all design decisions you make, and include any design calculations. If the information given is not enough to complete a design detail, explain the reason why.

In drawing your circuit, it is not necessary to draw microcontroller pins which have no connection made to them.

Question 1 continued overleaf

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Question 1 continued

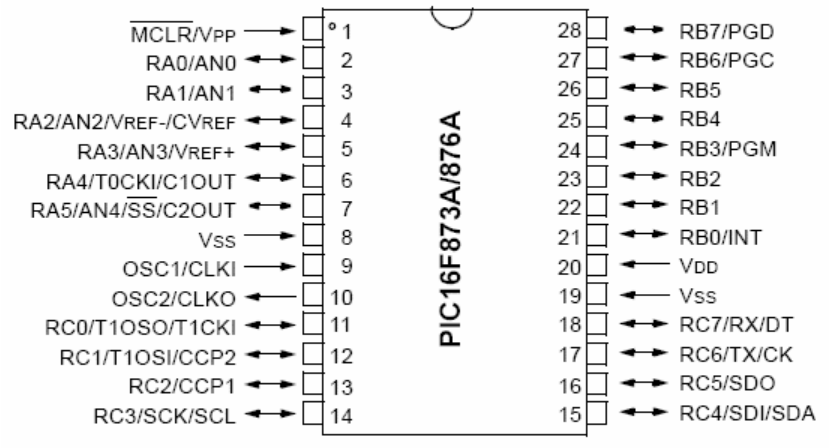
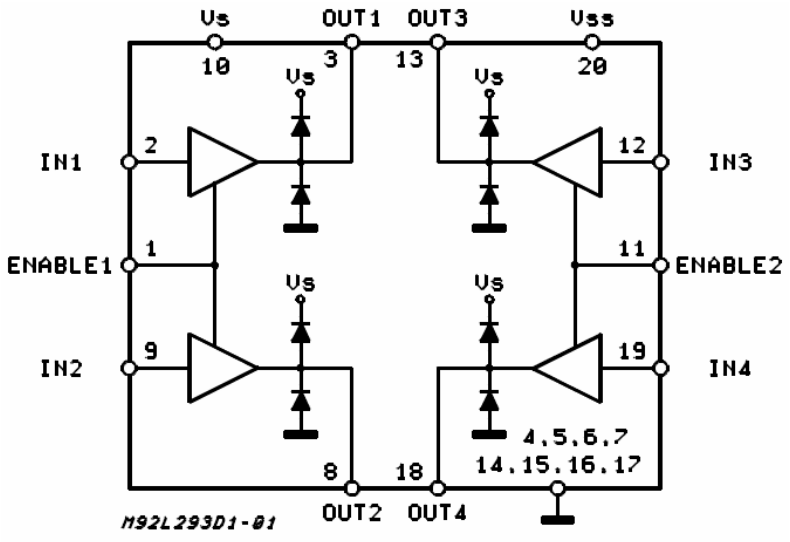


Fig. Q1.1



Key: V_{SS} = Logic Supply. V_S = Output Supply. V_S must be $\geq V_{SS}$.

Fig. Q1.2

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Question 2

(a) PWM (Pulse Width Modulation) is a technique widely used to control the speed of DC motors. Explain, using diagrams as appropriate, the principle of this speed control technique in as much detail as you can. You may if you wish make reference to the circuit diagram of Fig. Q2.1, but you do not have to do this.

(40%)

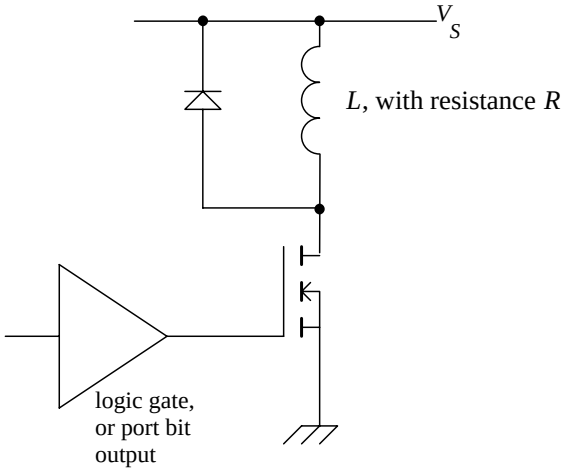

Fig Q2.1

Question 2 continued overleaf

Question 2 continued

(b) The block diagram of the PWM module of the 16F873A is shown in Fig. Q2.2. CCPR1L, CCPR1H, and PR2 are all registers that the program can write to or read from. The block diagram of the Timer 2 module, which works with the PWM module, is shown in Fig. Q2.3.

The two modules mentioned are operating in a microcontroller whose oscillator frequency, F_{OSC}, is 4MHz. The Timer 2 prescaler is initially set to 1:4, the PR2 register is loaded with a value 240 (decimal), and the CCPR1H with a value of 30 (decimal).

i) Which register controls the period of the PWM waveform, and which register controls the “on” time?
ii) For the settings described, what is the resulting PWM period?
iii) For the settings described, what is the approximate resulting “on” time?

(40%)

(c) Apart from motor control, PWM can also be used as a simple digital to analogue converter. Describe briefly how this can be done, and what external circuitry would be needed to implement this.

(20%)

Question 2 continued overleaf

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Question 2 continued

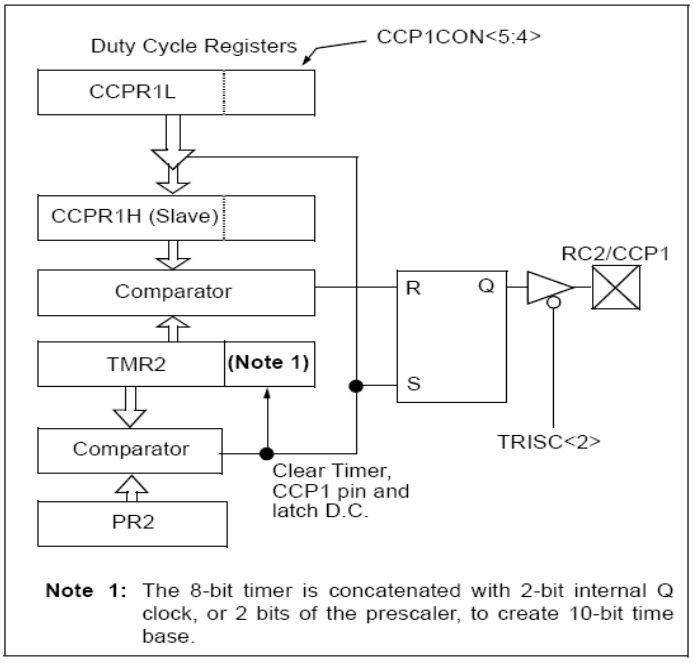

Fig Q2.2

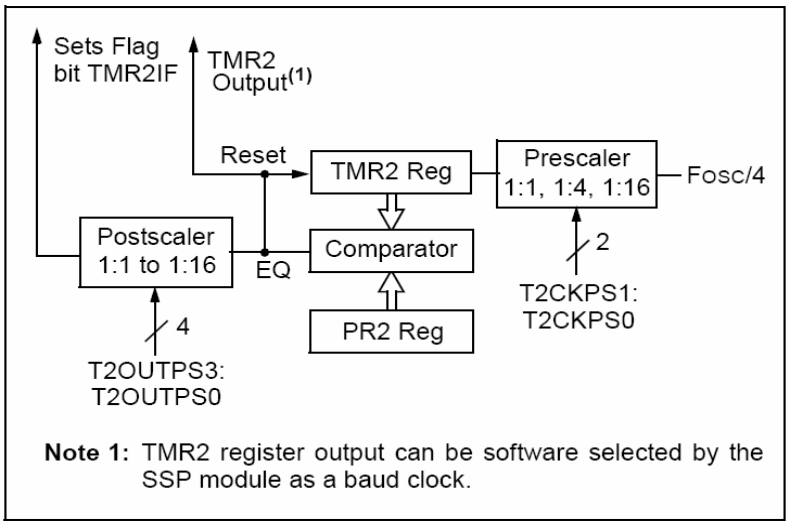

Fig Q2.3

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Question 3 - Answer *either* A *or* B

(A) Explain clearly the advantages and disadvantages of using Assembler when programming embedded systems. Describe in overview an alternative programming language, and its relative advantages and disadvantages. How is one disadvantage of this alternative language overcome?

(B) An embedded system is to be designed to run from battery power. The system must remain powered, but will have short periods of activity, separated by long periods of inactivity.

(i) Explain the impact of clock frequency on power consumption.
(ii) Describe in as much detail as you can a feature of the 16F873A microcontroller that can be used to minimise power consumption.
(iii) What other techniques of circuit design can be applied, to minimise power consumption.