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 (RESIT)

DATE: AUGUST / SEPTEMBER 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 hand-held motor controller controls two DC motors. It is based on the 16F873A microcontroller, shown in Fig. 1.

For *each* motor there is:

- a PWM (pulse width modulation) output signal, which sets its speed,
- an "enable" signal – when at logic high it enables the drive interface circuit which drives the motor,
- a push button labelled "UP", which increases the motor speed,
- a push button labelled "DOWN", which decreases the motor speed,
- a push button labelled "STOP", which disables the motor by setting the enable line low,
- an led (light emitting diode) which illuminates when maximum PWM rate has been reached.

Each motor has a drive interface circuit. This can be shown as a block, with PWM input, enable input, two output connections to the motor, power supply and ground. The interface circuit requires a 5V supply.

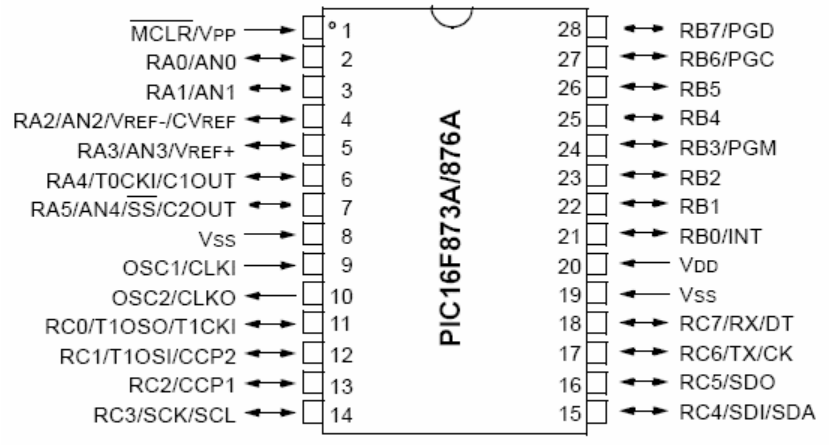
Draw a design for the microcontroller circuit, ***in the form of a detailed circuit diagram***. Include all aspects necessary to make a complete and working circuit, representing the drive interface as the blocks described in the above paragraph. The microcontroller should be powered from 5V, the source of this power need not however be shown.

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

Question 1 continued overleaf

Question 1 continued

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



Note: PWM outputs are available from the pins labelled CCP1, CCP2.

Fig. 1

TURN OVER

Question 2

The block diagram of the PIC 16F873A analogue to digital converter (ADC) is shown in Fig. 2, and the ADCON0 register which partly controls it in Fig. 3.

a) What is the setting of the ADCON0 register if an external voltage reference and internal ADC oscillator are required, input channel 2 is selected, and the ADC is switched on but not running?

(20%)

b) What are the relative advantages in using an external or an internal (VDD) voltage reference?

(20%)

c) When applying the ADC, a series of operations must take place in order to make a single conversion. Describe each of these, along with any precautions which need to be taken. Indicate what determines the time duration of each operation.

(60%)

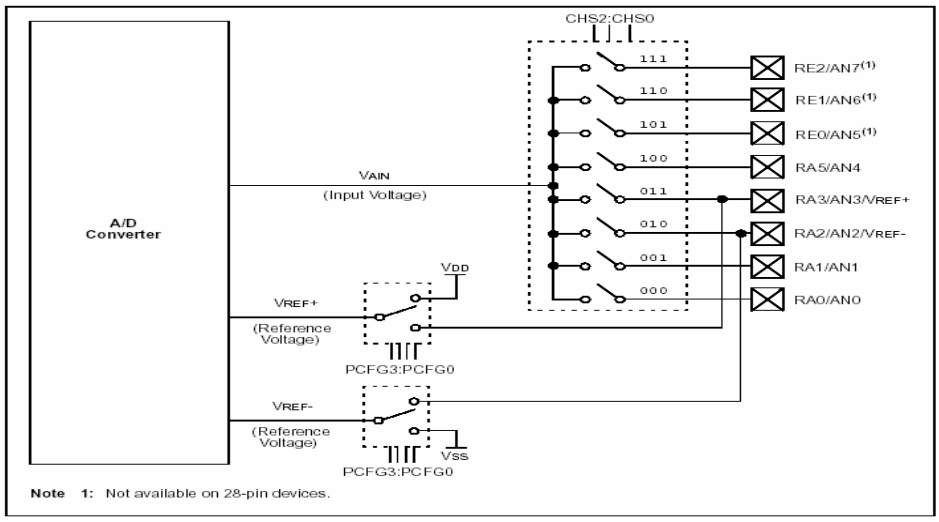


Fig. 2

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R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	R/W-0	U-0	R/W-0
ADCS1	ADCS0	CHS2	CHS1	CHS0	GO/$\overline{\text{DONE}}$	—	ADON
bit 7							bit 0

bit 7-6 **ADCS1:ADCS0:** A/D Conversion Clock Select bits (ADCON0 bits in bold)

ADCON1 <ADCS2>	ADCON0 <ADCS1:ADCS0>	Clock Conversion
0	00	Fosc/2
0	01	Fosc/8
0	10	Fosc/32
0	11	FRC (clock derived from the internal A/D RC oscillator)
1	00	Fosc/4
1	01	Fosc/16
1	10	Fosc/64
1	11	FRC (clock derived from the internal A/D RC oscillator)

bit 5-3 **CHS2:CHS0:** Analog Channel Select bits

000 = Channel 0 (AN0)
001 = Channel 1 (AN1)
010 = Channel 2 (AN2)
011 = Channel 3 (AN3)
100 = Channel 4 (AN4)
101 = Channel 5 (AN5)
110 = Channel 6 (AN6)
111 = Channel 7 (AN7)

Note: The PIC16F873A/876A devices only implement A/D channels 0 through 4; the unimplemented selections are reserved. Do not select any unimplemented channels with these devices.

bit 2 **GO/$\overline{\text{DONE}}$:** A/D Conversion Status bit

When ADON = 1:

1 = A/D conversion in progress (setting this bit starts the A/D conversion which is automatically cleared by hardware when the A/D conversion is complete)
0 = A/D conversion not in progress

bit 1 **Unimplemented:** Read as '0'

bit 0 **ADON:** A/D On bit

1 = A/D converter module is powered up
0 = A/D converter module is shut-off and consumes no operating current

Fig. 3

TURN OVER

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. How is one disadvantage of this alternative language overcome?

B) Many embedded systems are designed to be run from battery power. Power consumption must therefore be minimised in every way possible.

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.