UNIVERSITY OF DERBY

School of Computing and Technology

EXAMINATION PAPER

BSc/BSc (HONS) MUSIC TECHNOLOGY AND AUDIO SYSTEM DESIGN
BSc/BSc (HONS) LIVE PERFORMANCE TECHNOLOGY
BSc/BSc (HONS) ELECTRICAL AND ELECTRONIC ENGINEERING
LEVEL SIX

EMBEDDED SYSTEMS
6EJ005

DATE: SUMMER 2003

TIME ALLOWED: 2 HOURS

Instructions to Candidates

1. Answer *all three* questions.
2. All questions carry equal marks.

DO NOT TURN OVER UNTIL INSTRUCTED

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1. A domestic central heating controller is to be designed. The heating system will have a single boiler, but can independently control *two* zones, the upstairs and downstairs of the house.

   Each zone has its own pump, temperature sensor, and led indicator, and requires the following set of signals:

Signal Name	**Type**	**Description**
Pump	output	Logic 1 switches on if heating required, negligible current required
Temperature sensor	input	Logic 0 if measured temperature too low
Over-ride ON	input	Push-button switch, Logic 1 forces heating ON
Over-ride OFF	input	Push-button switch, Logic 1 forces heating OFF
LED	output	Logic 1 lights led, showing heating is on; led requires 15mA, and have a forward voltage when in conduction of 1.9V.

   In addition to these, the following *system* signals are required, which will affect both zones:

Signal Name	**Type**	**Description**
Boiler	output	Logic 1 output if either or both zones require heating, negligible current required
Clock	output	2 serial lines driving a liquid crystal display negligible current required

i) The system controller is to be based on the 16F84 microcontroller powered with 5V, whose pinout is shown in Fig. Q1.1. Draw a suggested circuit diagram for it. Your diagram should show all signal interconnections, and any other connections and components required to complete the circuit. These should include leds, switches and their associated components, with component values. Make use of the data in Fig Q 1.2 as needed. Boiler, pumps, liquid crystal display, and temperature sensors can just be represented as blocks. You may omit components associated with the clock oscillator.

80%

ii) The Special Function Registers which set data direction for Ports A and B are called TRISA and TRISB. A 0 in any bit of TRISA/B sets the corresponding port bit to output. Show how your programme would set these, for your circuit in part i).

20%

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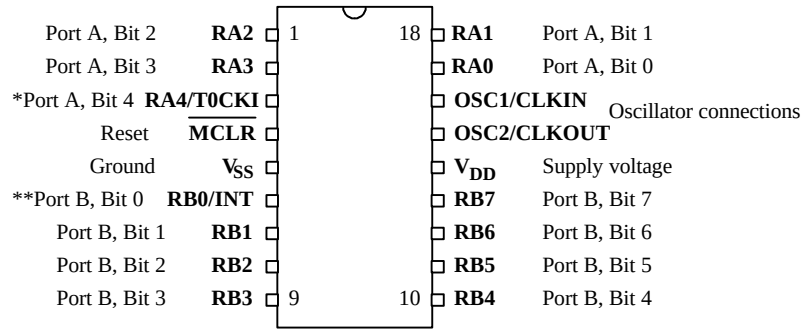
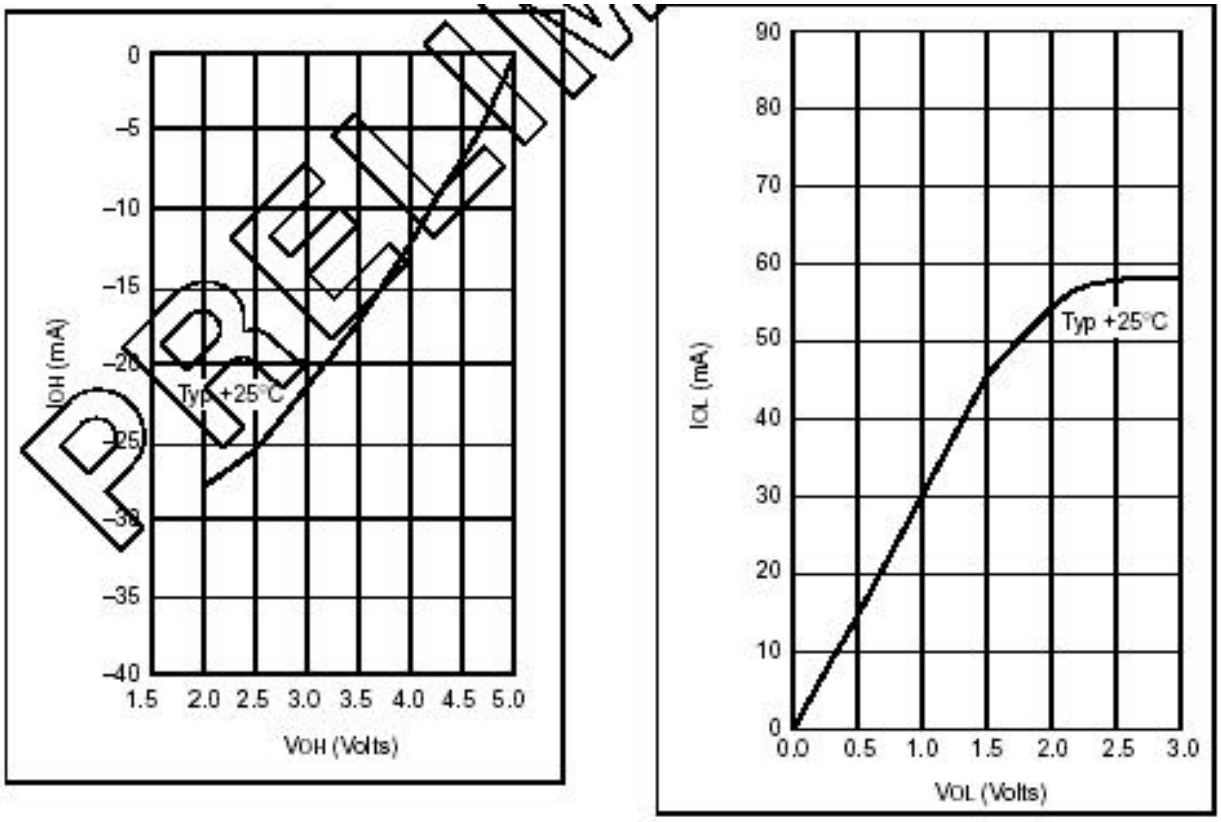


*also Counter/Timer clock input

**also external Interrupt input

Fig Q1.1



Key: V_{OH}: output voltage, logic high I_{OH}: output current, logic high
V_{OL}: output voltage, logic low I_{OL}: output current, logic low

Fig Q1.2

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2. An 8-bit Counter/Timer peripheral is shown in Fig Q2.1, with related Special Function Registers (SFRs) shown in Fig Q2.2. The Internal Oscillator runs at a quarter the frequency of the external crystal oscillator.

   i) The Counter/Timer is initiated by loading its Control SFR with value 00110111. The Internal Oscillator signal has a frequency of 4MHz.

      a) Under these conditions, what is the signal frequency at the input to the Counter, i.e. point X in fig Q2.1?

      b) If the counter is initially cleared to zero, how long does it take before it first overflows?

      c) What is the value of both SFRs in Fig Q2.2 immediately after this overflow occurs?

      40%

   ii) It is intended to use this Counter/Timer to generate a regular interrupt. The interrupt must occur every 5ms. Crystal oscillators are available, at the following frequencies: 1.0MHz, 1.8432MHz, 2.0MHz, 2.457MHz, 3.277MHz, 3.579MHz, and 4.0MHz. Recommend one crystal, and indicate how the Control SFR should be set, to achieve this objective.

      50%

   iii) What is a possible application for the setting described in part ii) of this question?

      10%

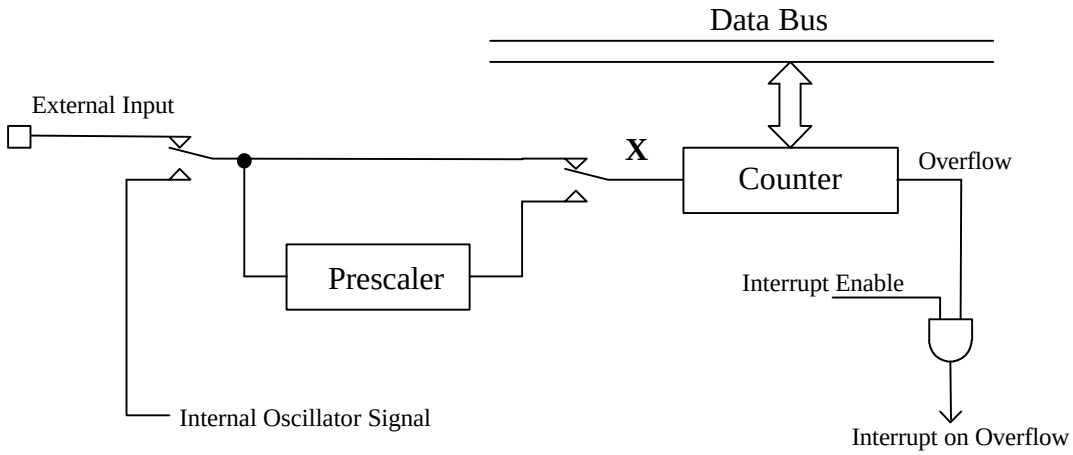

Fig. Q2.1

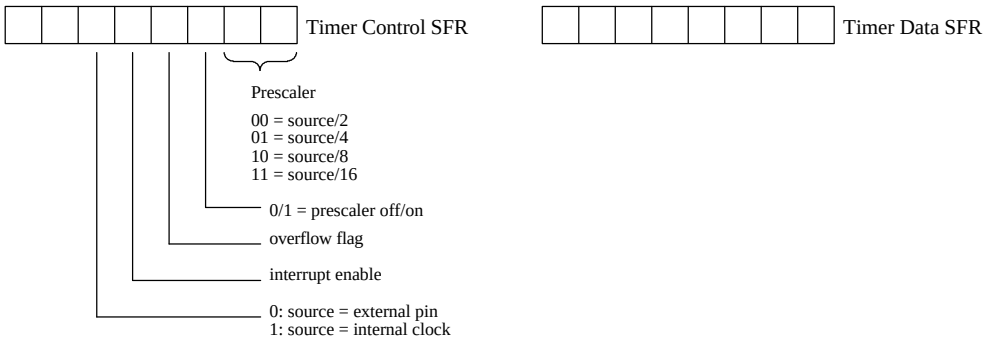
Timer Control SFR
Timer Data SFR
Prescaler
00 = source/2
01 = source/4
10 = source/8
11 = source/16
0/1 = prescaler off/on
overflow flag
interrupt enable
0: source = external pin
1: source = internal clock

Fig. Q2.2

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3. i) A battery-powered embedded system is to have three memory areas:

   1) Programme memory: must be non-volatile, but if possible it should be possible to re-programme occasionally, with minimum disturbance to the system;

   2) Data memory: can be volatile;

   3) Non-volatile Data Memory: used to hold user-determined settings.

   Recommend an appropriate memory technology for each of these memory areas. Explain in outline how that technology works, and describe its principle characteristics, advantages and disadvantages.

   60%

   ii) In the embedded system mentioned in i) above, consideration is being given to using a separate serial-linked integrated circuit for the non-volatile data memory. Name one serial protocol which could be used for this purpose. Describe its characteristics, and advantages for this application.

   40%