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
BSc (HONS) ELECTRONICS
LEVEL SIX

EMBEDDED SYSTEMS
6EJ005

DATE: SUMMER 2007

TIME ALLOWED: 2 HOURS

Instructions to Candidates

1. Answer all *three* questions. Note that there is a choice *within* Question 3.
2. All questions carry equal marks.

DO NOT TURN OVER UNTIL INSTRUCTED

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Question 1

A 16F873A microcontroller is to be used as the basis of a greenhouse climate controller. It has the following sensors, actuators, and interfaces:

Sensors
Temperature sensor: outputs a signal of 100mV/^{o}C.
Soil Moisture sensor: outputs a linear signal in the range 0V (very dry) to 4.5V (saturated).
Light Sensor: outputs a linear signal whereby 0V is completely dark, 4V is bright sunlight.

Actuators (all activated by a logic signal)
Water sprinkler,
Heater,
Artificial Light Source.

Interfaces
Light Emitting Diode, indicating control function is active,
A modular user interface with keypad and display, with I^2C interconnection.

In simple terms, the control system monitors light intensity and duration, soil moisture, and temperature, and activates the actuators as necessary. Operational settings can be varied by the user through the user interface. The system is to be powered by 5 AA alkaline cells, while actuators receive their power independently.

Question 1 continued overleaf

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i) 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. Each sensor, actuator, and interface may be shown as a block, connected as appropriate to the microcontroller. The 16F873A pin connection diagram is given in Fig. 1. In drawing your circuit, it is not necessary to draw microcontroller pins which have no connection made to them.

(60%)

ii) 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.

(30%)

iii) Explain briefly how Ports A, B and C will need to be configured for your design.

(10%)

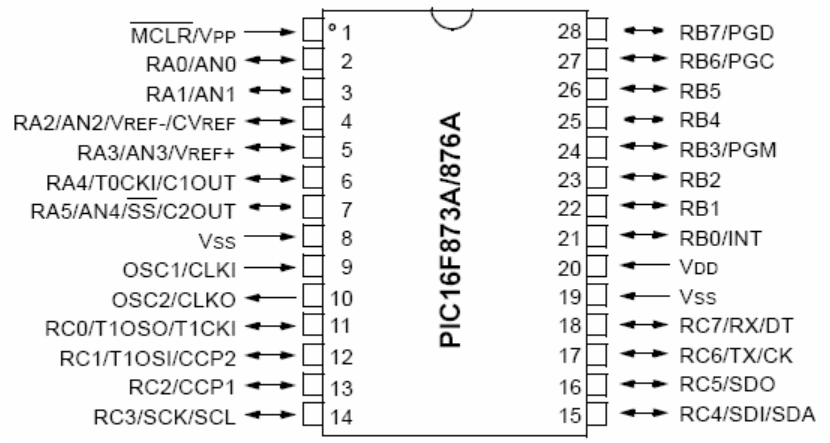

Fig. 1

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2. i) While investigating the operation of a certain microcontroller-based system, the serial signals shown in Fig. 2 are observed on an oscilloscope. Identify each, giving as much information about it as you can.

(30%)

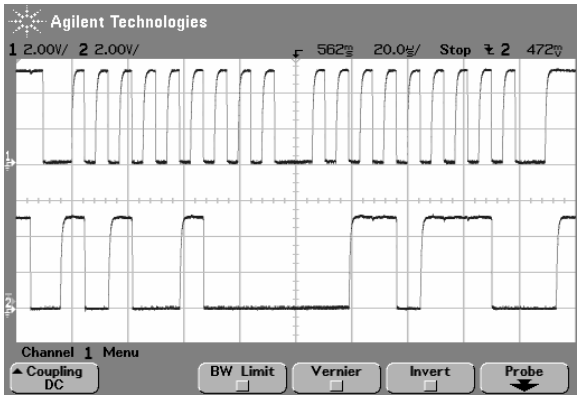


Fig. 2a)

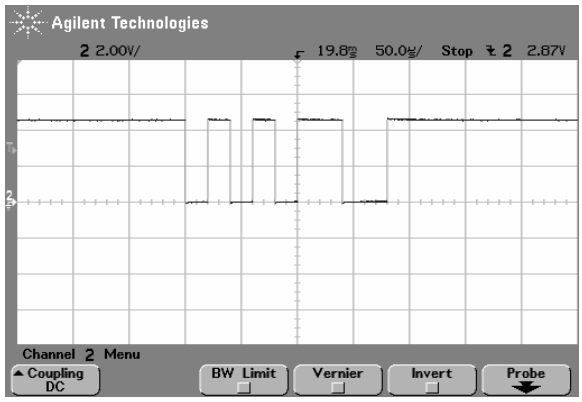


Fig. 2b)

ii) A pin diagram of the MAX538 Digital to Analogue Converter is shown in Fig. 3a). It is intended to connect it to the Master Synchronous Serial Port (MSSP) module of a PIC 16F873A microcontroller, when configured in SPI (Serial Peripheral Interface) Mode, as shown in Fig. 3b).

Draw a simple block diagram that shows how the interconnection must be made. Show only the detail necessary to complete this interconnection, and nothing else.

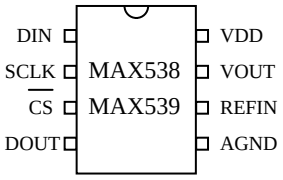
(25%)

iii) In a development of the application outlined in part ii), four of the MAX538 Digital to Analogue Converters are now required, all driven from the same 16F873A serial port. Show, again using a block diagram, how that interconnection can be achieved.

(25%)

iv) You are embarking on the design of a very high reliability embedded system, where serial data transfer is required. Name a suitable serial protocol, and outline a few of its key features.

(20%)



DIN: Data Input
SCLK: Serial Clock
CS: Chip Select
DOUT: Data Output
VDD: Supply Voltage
VOUT: Analogue Output Voltage
REFIN: Reference Voltage Input
AGND: Analogue Ground

Fig 3a)

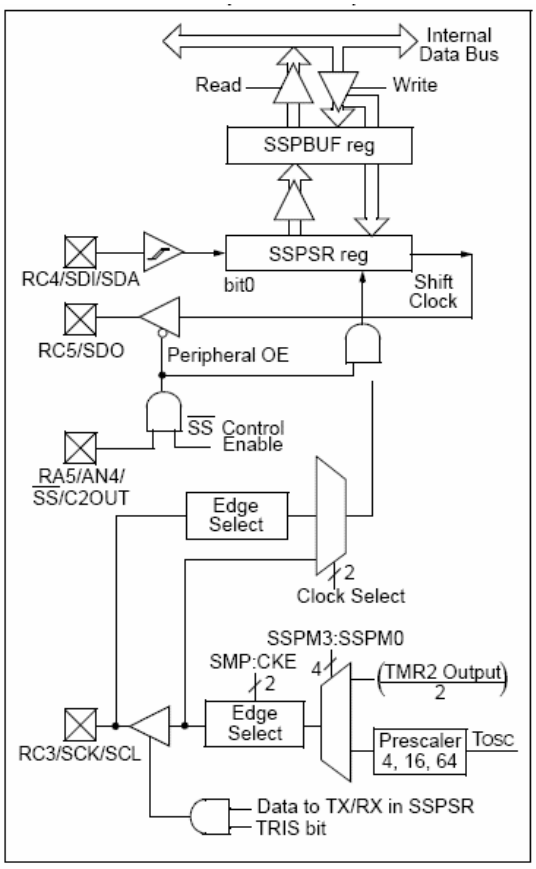


Fig. 3b)

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3. Answer ***ONE*** of A, B or C.

A. i) Explain clearly the advantages and disadvantages of using Assembler when programming embedded systems.

(50%)

ii) Describe in overview an alternative programming language, and its relative advantages.

(25%)

iii) Describe how one *disadvantage* (in the context of embedded systems) of this alternative language is overcome.

(25%)

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.

(30%)

ii) Describe in as much detail as you can features that you would expect to find on a power-conscious microcontroller, which can be used to minimise power consumption.

(40%)

iii) What other techniques of circuit design can be applied, to minimise power consumption.

(30%)

TURN OVER

C. Most embedded systems need to engage in multitasking. To do this, they sometimes make use of a Real Time Operating System (RTOS).

i) In the context of an RTOS, explain the following terms, using diagrams if appropriate:

a) task
b) priority
c) clock tick
d) round robin scheduling
e) pre-emptive scheduling

(60%)

ii) You are working for a company which has developed a certain microcontroller-based product over a period of time, of gradually increasing complexity. Describe programme or product characteristics which would indicate that it is appropriate to consider the use of an RTOS.

(20%)

iii) Describe briefly the *disadvantages,* both technical and commercial, of using an RTOS.

(20%)