UNIVERSITY OF LONDON
IMPERIAL COLLEGE OF SCIENCE, TECHNOLOGY AND MEDICINE

EXAMINATIONS 2001

BEng Honours Degree in Computing Part III
for Internal Students of the Imperial College of Science, Technology and Medicine

*This paper is also taken for the relevant examinations for the Associateship of the City and Guilds of London Institute*

# PAPER C334

# MICROCONTROLLERS AND COMPUTER INTERFACING

Thursday 3 May 2001, 14:00
Duration: 120 minutes

*Answer THREE questions*

Paper contains 4 questions
Calculators not required

1 a A proportional controlled feedback loop is an effective way of ensuring that a DC motor runs at a constant speed. To achieve smooth control the loop must be executed at a suitable rate, unfortunately the definition of "suitable" will vary according to a variety of factors. What factor will effect the *maximum* rate at which the loop should be executed (excluding processor constraints) and what would be the effect on the quality of the control if this limit were too low?

b A second factor that has to be determined empirically is the proportional constant multiplier. What is the effect of having too high and too low a value for this constant?

c How can you extend the structure of a single closed loop feedback control to account for keeping two DC motors in step, thus providing straight line control?

d How can your answer of part b be extended to allow for controlled cornering?

*The four parts carry, respectively, 20%, 20%, 30%, 30% of the marks.*

2 a What are the parameters that effect the accuracy of an input transducer? Give a brief, one line, explanation of each parameter.

b A simple infra-red transmitter and detector pair can produce a low signal when a reflection is detected and a high signal when no reflection is detected. The intensity of the reflected light must exceed a certain threshold.

i) What steps can be taken to ensure that the detector is immune to ambient light?

ii) Why does the signal go low (rather than go high) when the reflection is detected?

c A single pole, two way switch is connected to the external interrupt input of a microcontroller which has been programmed to count the number of times the switch is opened and closed. The switched signal has been attenuated to ensure that it does not violate any electrical constraints of the input pin. In operation the microcontroller *appears* to count many openings and closings when the switch moves in *one* direction but correctly counts the movement of the switch in the *other* direction. Why does this strange asymmetrical behaviour occur and how can it be overcome in software?

*The three parts carry, respectively, 30%, 35% and 35% of the marks.*

3 The internal registers of an interface device are often addressed as if they were part of the processor memory address space. This memory mapping can be achieved through some form of address decoding which may be complete or incomplete and, if incomplete, degenerate addressing may be introduced.

a Outline a decoding schematic that would map a 24 bit address onto 64K bytes of ROM, 32K bytes of (degenerately addressed) RAM and 4 external devices each of which has 4 read only registers and 4 write only registers.

b Once the address decoding has been completed, the registers may be read or written using the same bus and protocol used to access main memory. However, the actual operation of the device (Conversion from Analogue to Digital for example) may take a considerable amount of time. List three different techniques for synchronising microcontroller code with the external devices. For each technique you should state some advantages and disadvantages as well as a typical environment where the technique would be appropriate.

*The two parts carry, respectively, 40%, 60% of the marks.*

4 A microprocessor has been interfaced to a simple Parallel Interface Adapter (PIA). A sample and hold circuit has been added that is triggered by an output of the PIA and the output of the Sample/Hold circuit is fed to an analogue comparator. The other side of the comparator is connected to the output of a ladder network providing a 4 bit Digital to Analogue converter. The 4 bit inputs of the D-A are connected to 4 pins of the PIA. Finally the output of the comparator is fed back to the PIA.

The microprocessor is to monitor an analogue signal which is conditioned and fed into the sample and hold circuit. Essentially, software in the microprocessor, must provide a 4 bit Analogue to Digital (A-D) converter.

a i Explain the terms *Aperture time* and *Acquisition time* and describe their role in limiting the maximum frequency of analogue signal that can be measured by our system

ii By means of a diagram, explain what is meant by an *alias* and why might our system be subject to them? What additional hardware or software would be required to eliminate aliases?

b Outline an algorithm that would minimise the A-D conversion time of the system (and thus maximise the frequency that can be tracked) for

i A signal that is a pure sine wave

ii A signal that changes rapidly but only by a small amount each time

c How could a 2 bit Flash A-D converter be integrated into the system to provide a faster 4 bit A-D converter? What changes to your proposed algorithms of part b would you make?

*The three parts carry, respectively, 30%, 40%, 30% of the marks.*