OLLSCOIL NA hÉIREANN, GAILLIMH
THE NATIONAL UNIVERSITY OF IRELAND, GALWAY

SPRING EXAMINATIONS 1999

THIRD YEAR ELECTRONIC ENGINEERING EXAMINATION

COMPUTER SYSTEMS ENGINEERING I

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Duration of Examination: **3 hours**

Instructions to candidates: Answer **FIVE** questions.
All questions carry equal marks.

1. (a) Explain what is meant by the terms "open-collector output" and "Tri-State output". Describe two application areas where gates with open-collector outputs are useful. What are the advantages and disadvantages of such gates ? Describe one application where gates with Tri-State outputs are useful.

[7 marks]

(b) For the circuit shown in Fig. 1, calculate the range in which the value of the pull-up resistor R_L should fall. The following values may be used for the relevant electrical characteristics of the logic gates: I_{oh} = -220 μA, I_{ih} = 45 μA, $V_{OH(min)}$ = 2.4 V, $V_{OL(max)}$ = 0.4 V, $I_{ol(max)}$ = 16 mA, I_{il} = -1.6 mA). You may assume that only one gate is "on" in the low output state.

[7 marks]

(c) Describe the main sources of power dissipation in CMOS devices, and show how power dissipation behaves with varying frequency in such devices. How does this behaviour compare to that of TTL devices ?

[6 marks]

2. (a) Design a combinational circuit with a 4-bit binary input, which will detect the presence of a prime number on the input. Draw a logic diagram of your design.

[8 marks]

(b) A monitoring system is attached to a bedridden patient in a hospital. A sensor S_1 determines whether the patient is asleep (S_1 = 1) or awake (S_1 = 0). An additional sensor (S_2) measures the patients vital signs, and issues a status signal in the form of a 4-bit binary number which indicates the patients condition. When all vital signs are normal and the patient is awake, S_2 should fall in the range 6 to 12; when the patient is asleep, the normal range for S_2 changes to between 2 and 8. Design an alarm system with a single active-high output which indicates if S_2 falls outside normal values.

[12 marks]

[cont'd ...]

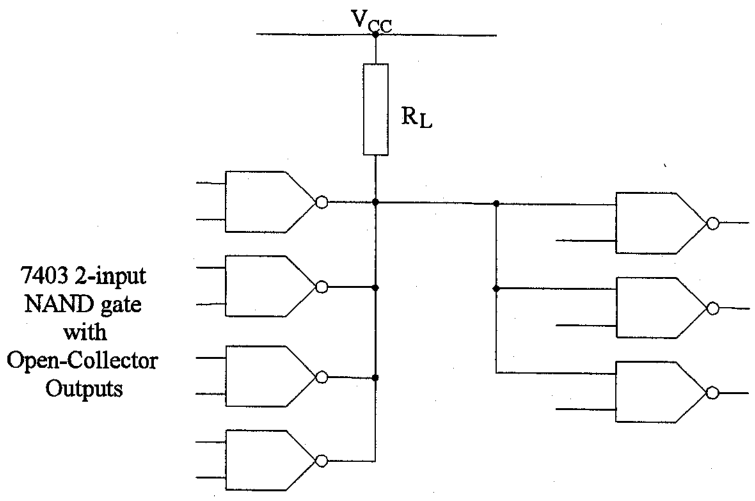

Fig. 1. Open-collector configuration (Q. 1)

3. (a) An engine has an inlet valve, an outlet valve, and a spark generator, and goes through a cycle of four strokes, of equal duration, in the following sequence: On the first stroke, the inlet valve is opened and the outlet valve is closed; on the second stroke, the inlet valve is closed (the outlet valve remains closed); on the third stroke, a spark is delivered; and during the fourth stroke, the outlet valve is opened for the exhaust from the explosion to vent. Design a controller for the system, using J-K flip flops. Assume there are three outputs, to control the inlet valve, the outlet valve and the spark generator.

[15 marks]

(b) Explain the following terms (i) metastability, and (ii) clock skew.

[5 marks]

4. (a) Explain how single-precision floating point numbers are stored according to IEEE Standard 754. Show how the following numbers would be stored according to this standard (single-precision):

(i) $1001.001_2 \times 2^6$;

(ii) -2113.625_{10}.

[10 marks]

(b) Explain why error detection and correction are necessary in the transmission of digital data. Show how error detection can be carried out in a data communications link by means of a Parity Bit. Include Boolean equations as appropriate (assume one parity bit is generated for every 7 data bits).

[4 marks]

(c) The source data word 1001 is to be transmitted using a $H_{7,4}$ Hamming code. Show how the check bits are calculated before transmission. If data bit D_2 is changed from a 0 to a 1 during transmission, show how the receiver carries out error detection and correction.

[6 marks]

5. An 8086-based PC is used in an alarm system to monitor the SO_2 emissions from a chemical plant (see Fig. 5). The SO_2 detector outputs an analogue voltage which is proportional to the SO_2 concentration. An analogue to digital converter (ADC) converts this voltage (0 - 255 mV) into an 8-bit unsigned binary number. A separate timing circuit provides a start convert pulse (SC) to the ADC at regular intervals, and, on receipt of an end-of-conversion signal (EOC) from the ADC, enables the INTR input of the 8086. The Interrupt Service Routine (ISR) for this interrupt (vector number 50) reads the 8-bit number from Port A of the 8255, and, if the voltage is greater than or equal to 100 mV, sounds an alarm by outputting a square wave (frequency 5 kHz and duty cycle 50%) continually on PC_0. A human operator must then intervene to manually reset the computer and attend to the alarm. Write an Assembly language program and Interrupt Service Routine to accomplish this.

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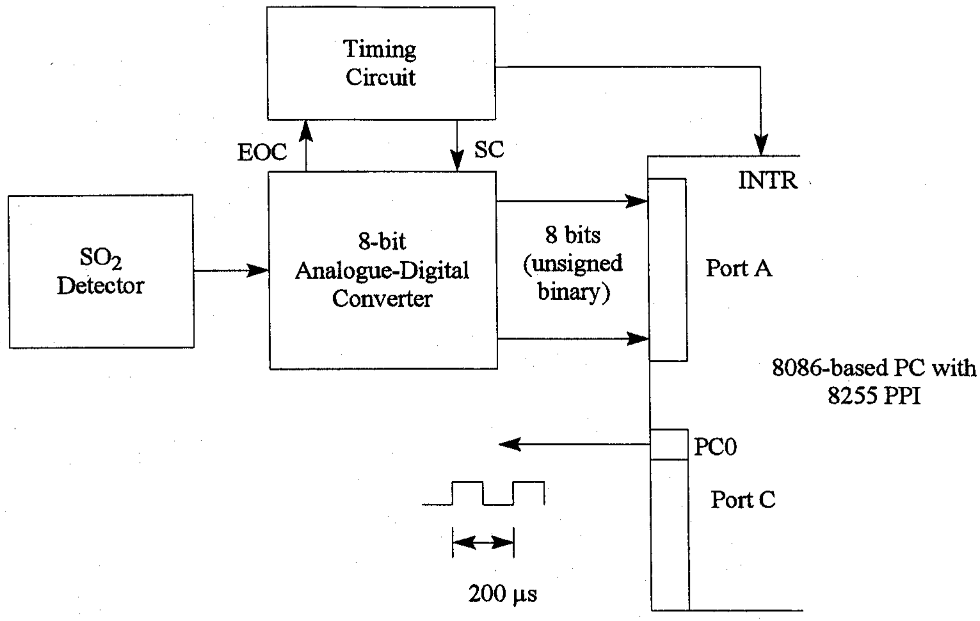

Fig. 5. Block diagram of SO_2 alarm system (Q.5).

The following points should be noted:
(i) The ISR for the interrupt is stored at location 20000H in memory.
(ii) The control word required to configure the 8255 is 90H; the base address of the 8255 is 0300H.

[20 marks]

6. An 8086-based personal computer with an 8255 Programmable Peripheral Interface (PPI) is to be used to implement a proximity indicator. This indicator will give the distance to an object in cm (maximum distance is 99 cm). Signal processing circuitry is used to convert the analogue voltage from an ultrasonic transducer into an 8-bit BCD number representing the distance. The hardware configuration is illustrated in Fig. 6. You are required to write an Assembly language program to continually read the 8-bit BCD data from Port A of the PPI, and display the results on the 7-segment displays connected to Port B (less significant BCD digit) and Port C (more significant BCD digit).

The following points should be noted:
(i) The hexadecimal codes which must be sent to a 7-segment display to cause the digits 0-9 to appear are (in order) 3F, 06, 5B, 4F, 66, 6D, 7D, 07, 7F, 6F (hint: you should consider using a look-up table for these values).
(ii) You may ignore any delays required for analogue-to-digital conversion.
(iii) The control word required to configure the 8255 is 90H; the base address is 0500H.

[20 marks]

7. A simple digital control system is to be implemented using an 8086-based embedded system that includes an 8255 PPI. The control system is required to monitor an externally-generated signal from a sensor, and filter it using a first-order digital filter with the following difference equation:

$$y(n) = 0.5x(n) + 0.25y(n-1)$$

The input signal x(n) is available in binary form from an Analogue to Digital converter (ADC) connected to Port A of the 8255, while the output of the low-pass filter should be sent to a Digital to Analogue converter (DAC) connected to Port B. Timing is controlled by means of an external clock generation circuit connected to Bit 0 of Port C; when a low-to-high transition is detected on this bit, the PC should read in the input sample, process it using the digital filter, then send the filtered output to the DAC. It should then return and repeat the procedure indefinitely (or until a human operator manually resets the system).

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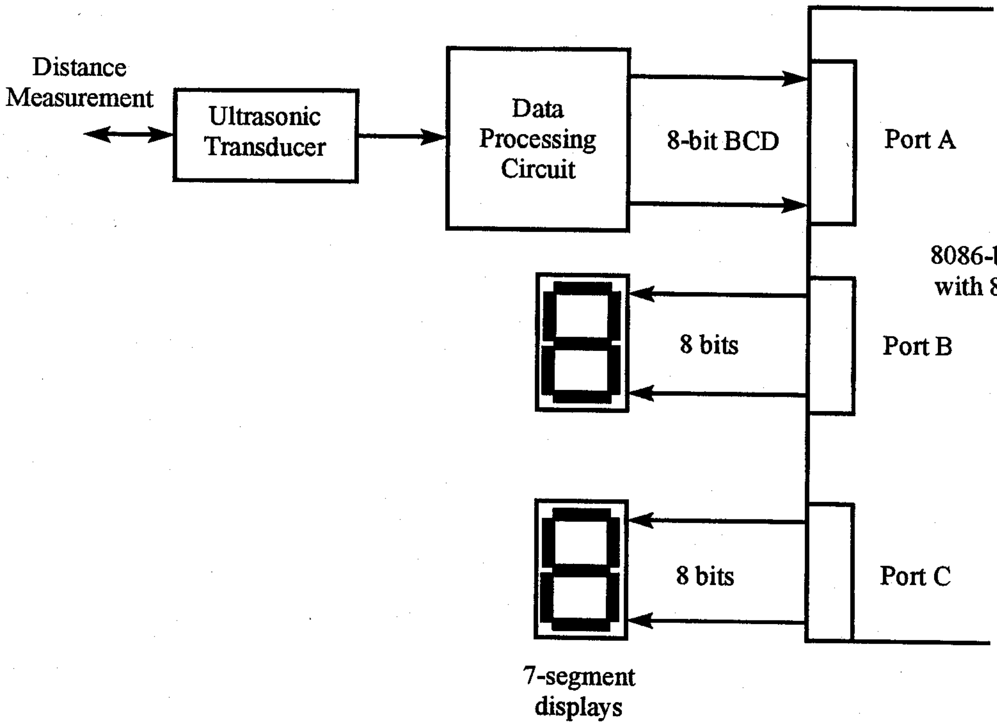

Fig. 6. Block diagram of proximity indicator (Q.6)

The following points should be noted:

(i) The control word required to configure the 8255 is 91H; the base address of the 8255 is 0400H.

(ii) You may assume that overflow will not occur during computational operations.

[20 marks]